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M Engine Management System

Model: All with S85 engine

Production: From Start of Production

OBJECTIVES

After completion of this module you will be able to:

- Understand the construction of the S85 V-10 engine
- Identify and locate components related to MS_S65 engine management
- Perform basic procedures related to MS_S65 engine management
- Diagnose concerns related to MS_S65 engine management

MS_S65 Engine Management System

In order to meet the demands of the S85 engine, the Siemens MS_S65 engine management system has been developed in conjunction with BMW M GmbH. The high-revving S85 engine complies with the EPA LEV 2 standards while maintaining reasonable fuel economy. This is only possible in conjunction with “world-class” engine management.

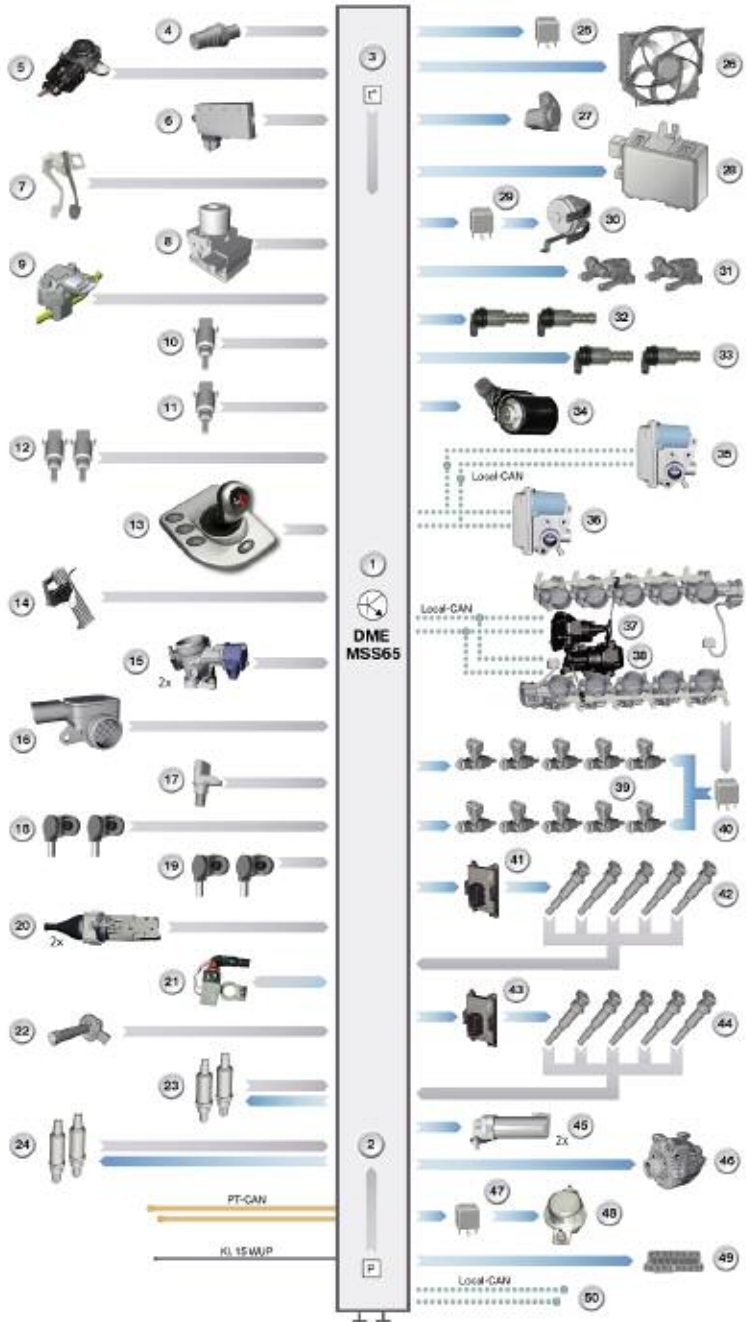
The DME control unit in the MS_S65 engine management system boasts the most powerful ECM to date. Found on the E60 M5 and E63 /E64 M6, the MS_S65 system is a further development of the MS_S54 engine management with some notable improvements.

The DME (ECM) is also responsible for monitoring over 50 input signals.

Some of the functions of the MS_S65 engine management include:

- Control and synchronization of 10 individual throttles
- Control of 2 electric oil “scavenging” pumps during cornering
- Demand oriented fuel delivery controlled by engine management
- The use of “ionic current measurement” for knock control and misfire detection



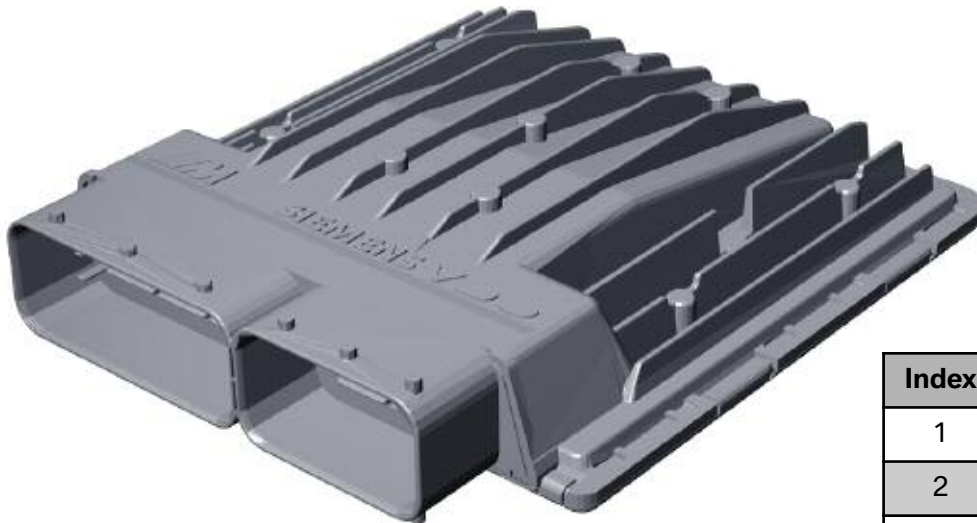
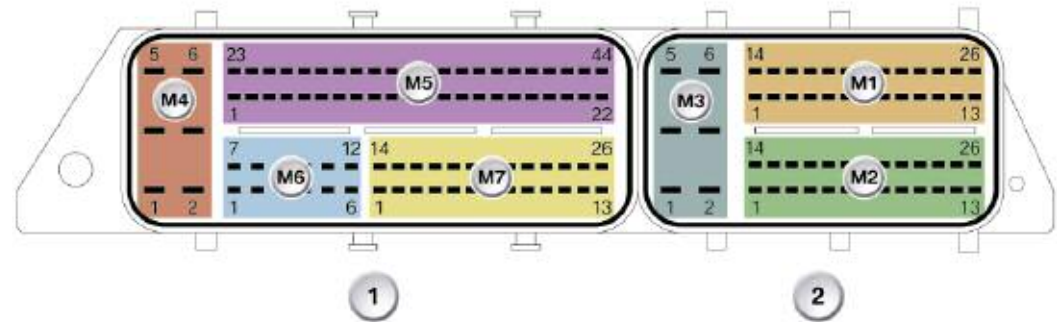


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2	Ambient Pressure Sensor	27	E-Box Cooling Fan
3	Ambient Temperature Sensor	28	EKP Module
4	Oil Pressure Switch	29	Secondary Air Pump Relay
5	Differential Pressure Sensor (X2)	30	Secondary Air Pump
6	Car Access System (CAS)	31	Fuel Tank Vent Valve (Purge Valve I and II)
7	Brake Light Switch (BLS)	32	VANOS Solenoids Bank I
8	Dynamic Stability Control (DSC)	33	VANOS Solenoids Bank II
9	Fuel Pressure Sensor	34	VANOS Pressure Accumulator
10	Radiator Outlet Temperature Sensor	35	Idle Control Valve (LLS) Bank I
11	Coolant Temperature Sensor	36	Idle Control Valve (LLS) Bank II
12	Exhaust Gas Temp. Sensor (I & II)	37	Throttle Control Motor (EDR) Bank I
13	Power Button	38	Throttle Control Motor (EDR) Bank I
14	Accelerator Pedal Module	39	Fuel Injectors (Bank I and II)
15	Throttle Valve Sensor (I and II)	40	Fuel Injector Relay
16	Mini HFM (for secondary air system)	41	Ionic Current Control Unit (Bank I)
17	Crankshaft Position Sensor	42	Ignition Coils (Bank I)
18	Camshaft Position Sensors (Bank I)	43	Ionic Current Control Unit (Bank II)
19	Camshaft Position Sensors (Bank II)	44	Ignition Coils (Bank II)
20	Hot Film Air Mass Meter (Bank I & II)	45	Electric Oil Pumps (I and II)
21	Intelligent Battery Sensor (IBS)	46	Alternator
22	Oil Condition Sensor (OZS)	47	Vacuum Pump Relay
23	Pre-Cat Oxygen Sensor (Bank I & II)	48	Vacuum Pump
24	Post-Cat Oxygen Sensor (Bank I & II)	49	DLC (Diagnostic Connector)
25	ECM (DME) Main Relay	50	Local CAN (Lo-CAN) to SMG

Control Module

The MS_S65 engine control module is manufactured by Siemens/VDO. The “MS_S” designation indicates that it is a Siemens/Motorsport engine management system.

The control module features an all-aluminum housing with a new modular connector configuration. The control unit has two main connectors, one with 4 modular “sub” connectors and the other with 3 for a total of 7 “sub” connectors.



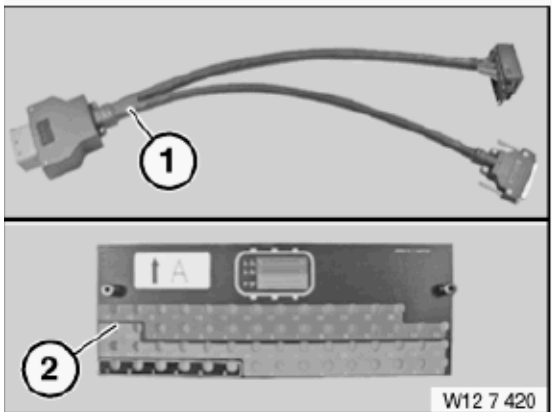
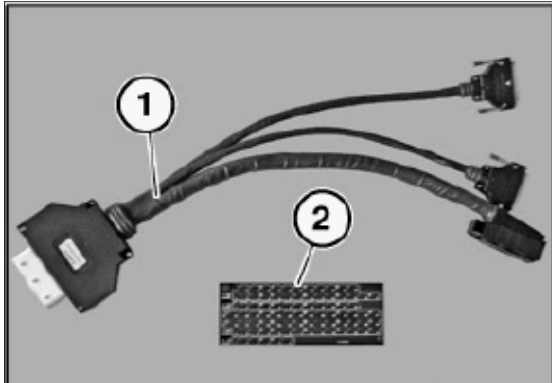
Index	Explanation	Index	Explanation
1	Connector X60004 to X60007	M4	Connector module 4 (6 pins)
2	Connector X60001 to X60003	M5	Connector module 5 (44 pins)
M1	Connector module 1 (26 pins)	M6	Connector module 6 (12 pins)
M2	Connector module 2 (26 pins)	M7	Connector module 7 (26 pins)
M3	Connector module 3 (6 pins)		

Processor Power

The computing power has been increased to meet the needs of the “high-revving” S85 powerplant. The DME (ECM) is capable of more than 200 million calculation per second. This is accomplished with three - 32 bit processors and a multi-layer circuit board with over 1000 individual parts.

Adapter Cables

The MS_S65 ECM requires the use of special breakout box adapter cables. These are carried over from the MSV70 engine management. These adapter are used with overlays to properly identify the pin connections during diagnosis.

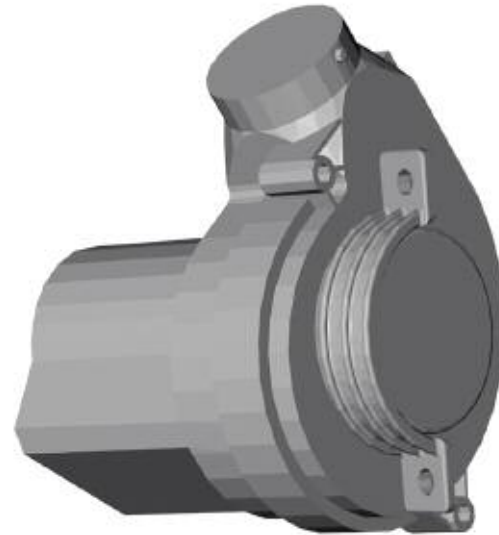


E-Box Fan

The E Box fan is controlled by ECM. The ECM contains an integral NTC temperature sensor for the purpose of monitoring the E box temperature and activating the fan.

When the temperature in the E-Box exceeds predetermined values, the ECM provides a switched ground for the E Box fan to cool the control modules located in the E-Box.

With every engine start-up, the ECM briefly activates the fan ensuring continued fan motor operation for the service life of the vehicle. This feature is intended to prevent fan motor “lock up” from lack of use due to pitting or corrosion over time.



Power Supply

Terminal 30 (KL30) Battery Voltage

The B+ power supply to the ECM comes from a 7.5amp fuse. On the M5 and M6, KL30 comes from fuse #26 (F26) which is located in the front fuse holder behind the glove box.

Engine Fuses

The engine electronics fuses are located in the E-box. However, there are now three separate fuse carriers in the E-Box. These fuses are supplied by KL87 from the ECM main relay.

The three fuse carriers are designated A8582, A8683 and A8680. The fuses in these carriers are designated as shown below.

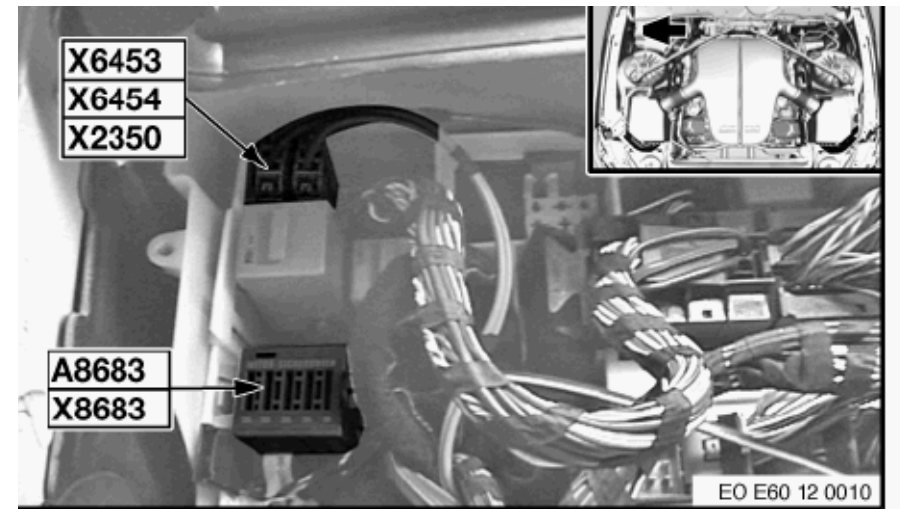
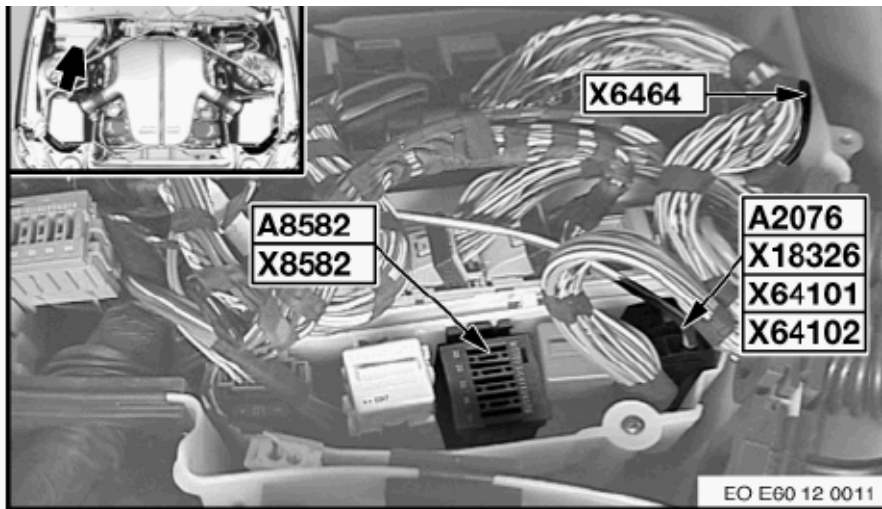
Terminal 15 (KL15)

As with previous vehicles equipped with PT-CAN, the ECM receives a KL15w via the bus network and a “hardwire” KL15 wake-up signal directly from the CAS.

When the ignition is switch “ON”, the ECM receives the wake-up signal via CAS, then it will energize the ECM main relay to supply power to the engine electronics fuse carrier to energize other engine related components and systems.

Ground (KL31)

There is a KL31 connection to the ECM at connector X60003 pin #4.



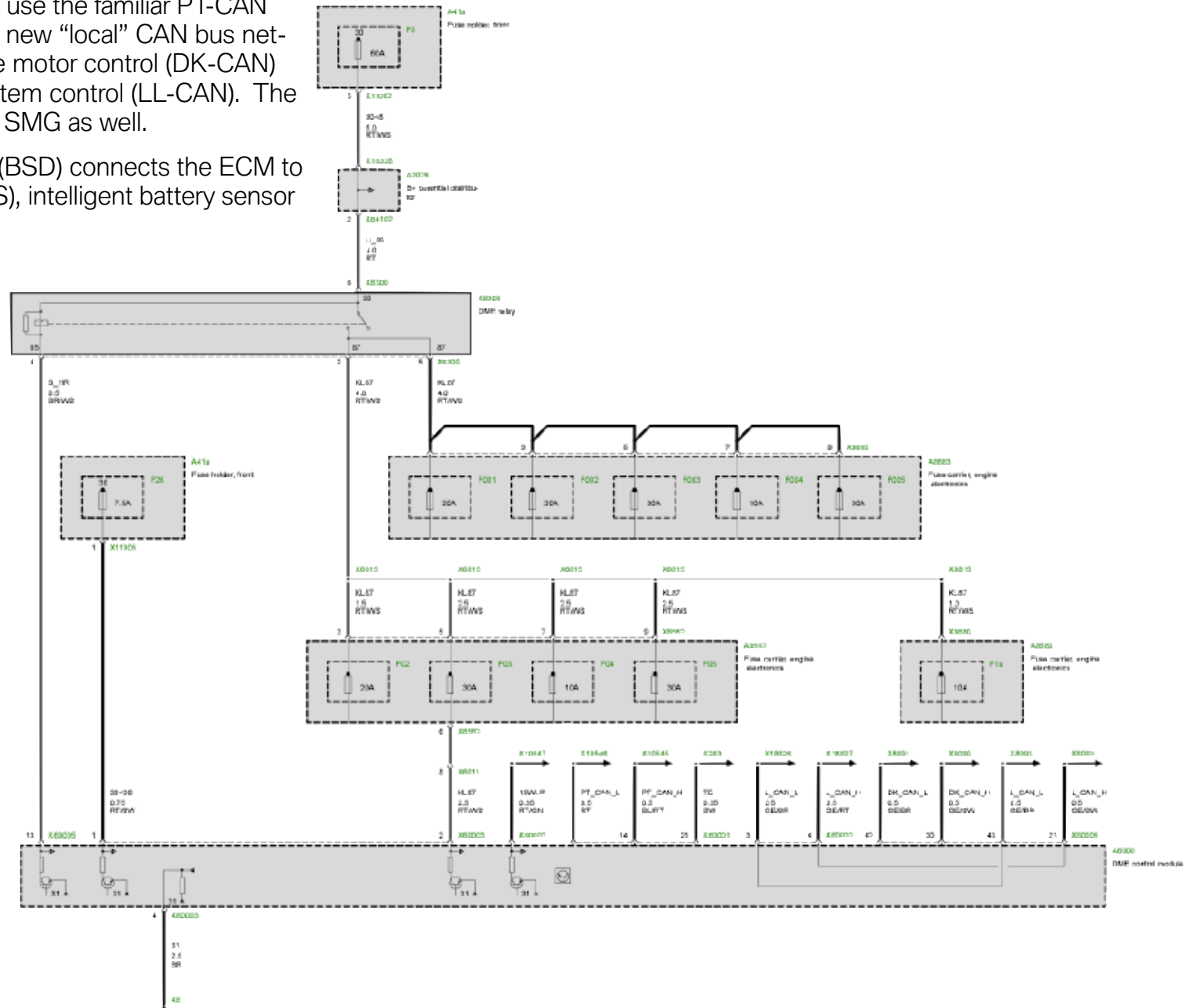
Fuse Carrier	Fuses
A8582	F02, F03, F04, F05
A8683	F001, F002, F003, F004, F005
A8680	F1a

Interfaces

The M5 and M6 continue to use the familiar PT-CAN bus. However, there are two new “local” CAN bus networks. One is for the throttle motor control (DK-CAN) and the other for the idle system control (LL-CAN). The LL-CAN is connected to the SMG as well.

The Bit-serial data interface (BSD) connects the ECM to the oil condition sensor (OZS), intelligent battery sensor (IBS) and the generator.

Power Supply Schematic



Air Management

Throttle System

As with previous “M” engine designs, there are individual throttles for each cylinder. The throttles are “bank” controlled via two EDR actuators (1 per bank). The 5 throttle valves on each bank are mechanically coupled with each other. Also, each cylinder bank has an idle control valve. Therefore, there are a total of 4 actuators for engine intake air control.

The two throttle actuator motors (EDR) and two idle control actuators (LLS) are connected to the ECM via separate local CAN bus systems. The throttle valve actuators are connected to the DK-CAN and the idle speed actuators are connected to the LLS/SMG CAN.



Throttle Valve Actuator

One actuator motor (EDR actuator) moves five mechanically coupled throttle valves on each cylinder bank. Each actuator consists of an electric motor with a gear mechanism and internal electronics.

The electronic control module within the EDR actuator allow the ECM (DME) to control, monitor and diagnose the throttles via the DK-CAN connection.

Due to the CAN connection between the actuators, synchronization of both banks can be carried out electronically.

In addition to the DK-CAN connection, there is a so-called “Enable line” (S_DK1/S_DK2) between the DME and throttle-valve actuator. Across this “Enable line”, the DME can switch off the throttle-valve actuator if there are communication faults on the DK-CAN.

Pin 4 on the throttle-valve actuator of bank 1 is switched to ground. This makes it possible to detect which throttle-valve actuator is fitted on which bank.

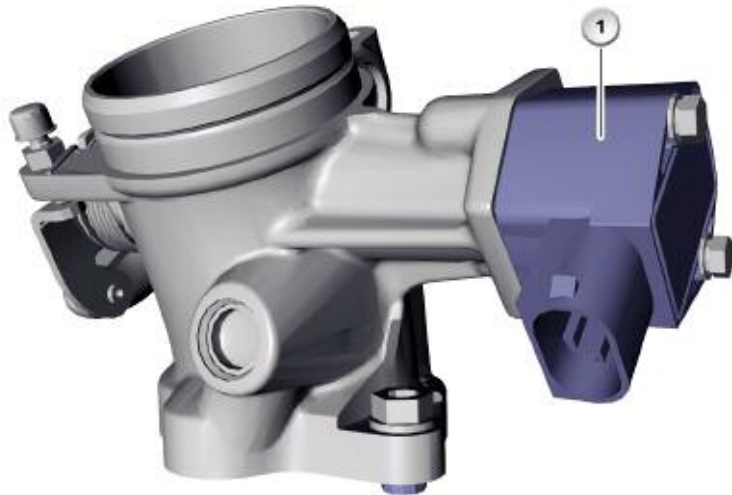


■ Throttle Valve Position Sensor (DKG)

There is one throttle valve position sensor (DKG) per bank. Each sensor contains 2 throttle position sensors (hall type) as well as internal electronics. The internal electronics make it possible for the throttle valve position sensor to communicate with the ECM (DME) via a local CAN bus. The local CAN bus is referred to as DK-CAN which uses the familiar three wire configuration.

One throttle valve position sensor is located on the throttle housing for cylinder 5 (bank I) and the other is located on the throttle housing for cylinder 6 (bank II). Each sensor contains 2 feedback hall sensors to detect throttle plate position.

One of the hall sensors is monitored by the EDR actuator which also supplies B+ power and ground (B-) for the sensor. The throttle position value is then sent to the ECM via the local CAN (DK-CAN).

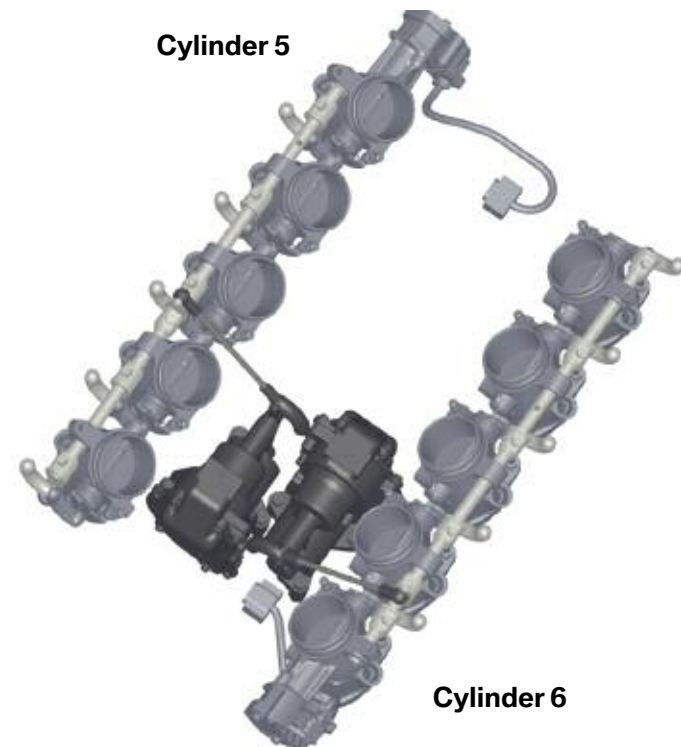


The sensor signal is “inverted” which means that the signal decreases as the throttle opens. In the event of failure, the affected EDR actuator unit is switched off.

A second hall sensor is responsible for monitoring (plausibility). It is powered and read by the ECM (DME). This hall sensor sends the signal with the “rising” characteristic in which the signal voltage increases as the throttle opens.

■ DK-CAN

There are two - 240 Ohm resistors, one in each EDR motor. The resistors are in parallel between DK-CAN-Hi and DK-CAN-Lo for a total resistance of 120 Ohms.



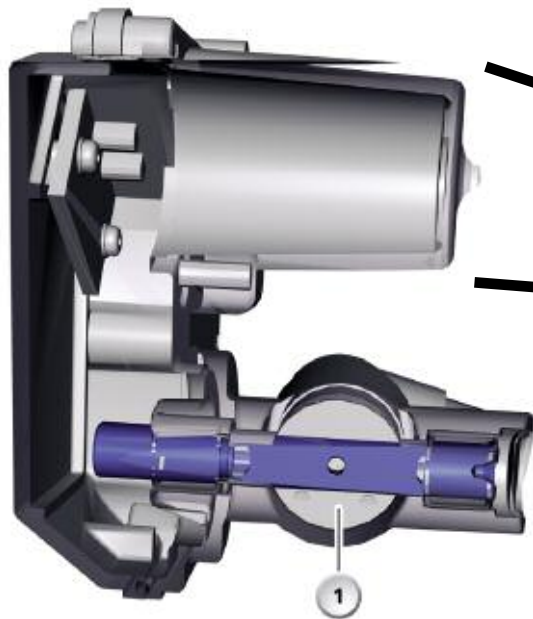
Idle Speed Actuator (LLS)

The two idle speed actuators use a “throttle type” design (1) and are in the “V-area” between the cylinder heads. In addition to the internal electric motor to control the idle valve “throttle plate, the LLS contains an incremental angle transducer for monitoring the position of the idle valve (plate).

This information is processed internally (in LLS) and communicated to the ECM via LLS/SMG-CAN. The idle speed actuators are initialized automatically when the engine is stationary and the ignition is ON.

At idle and low load conditions, the intake air is controlled by the 2 idle speed actuators. The idle actuators are controlled via the local CAN bus which connects the ECM (DME), the SMG and the 2 actuators (one LLS per bank).

Idle Speed Actuator (LLS)



The engine control module determines the current actual load signal from the throttle valve sensors (DKG) and feedback signals from the LLS actuators in order to check the setting of the throttle valves. The plausibility of the load signal is checked against the signals of the two hot-film air mass meters.

If the deviations between the target and actual load signals show any discrepancies, the plausibility is checked against the O2 sensors as well. The ECM will respond with the appropriate fault code if the situation falls outside the programmed parameters.

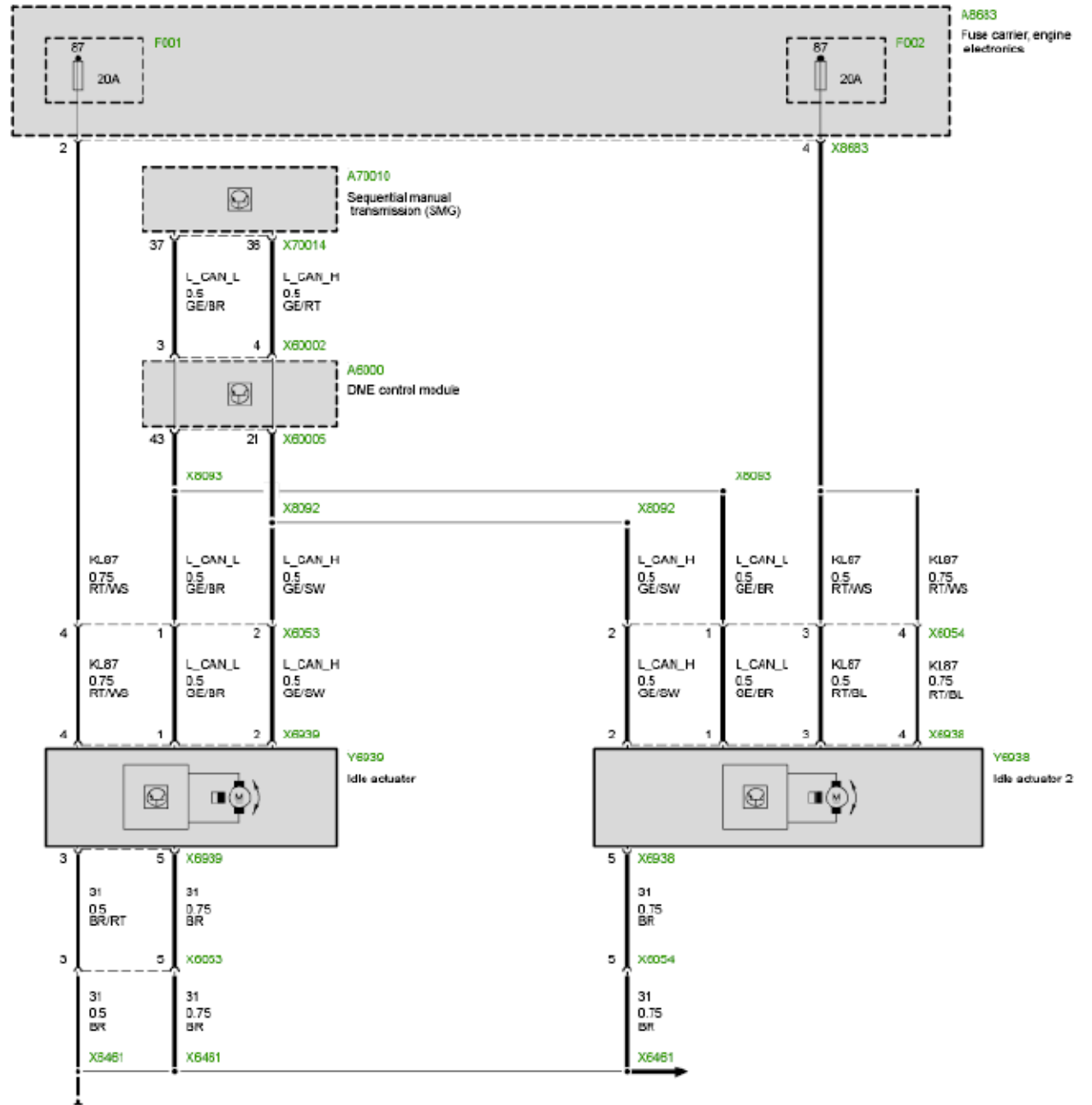
Similar to past systems the engine speed is controlled by the idle valves (LLS) until a certain load requirement is reached. This means that the potential for the idle throttle valves (LLS) will be exhausted before the individual throttle valves are opened. This allows an overall greater volume of air to be drawn into the engine.



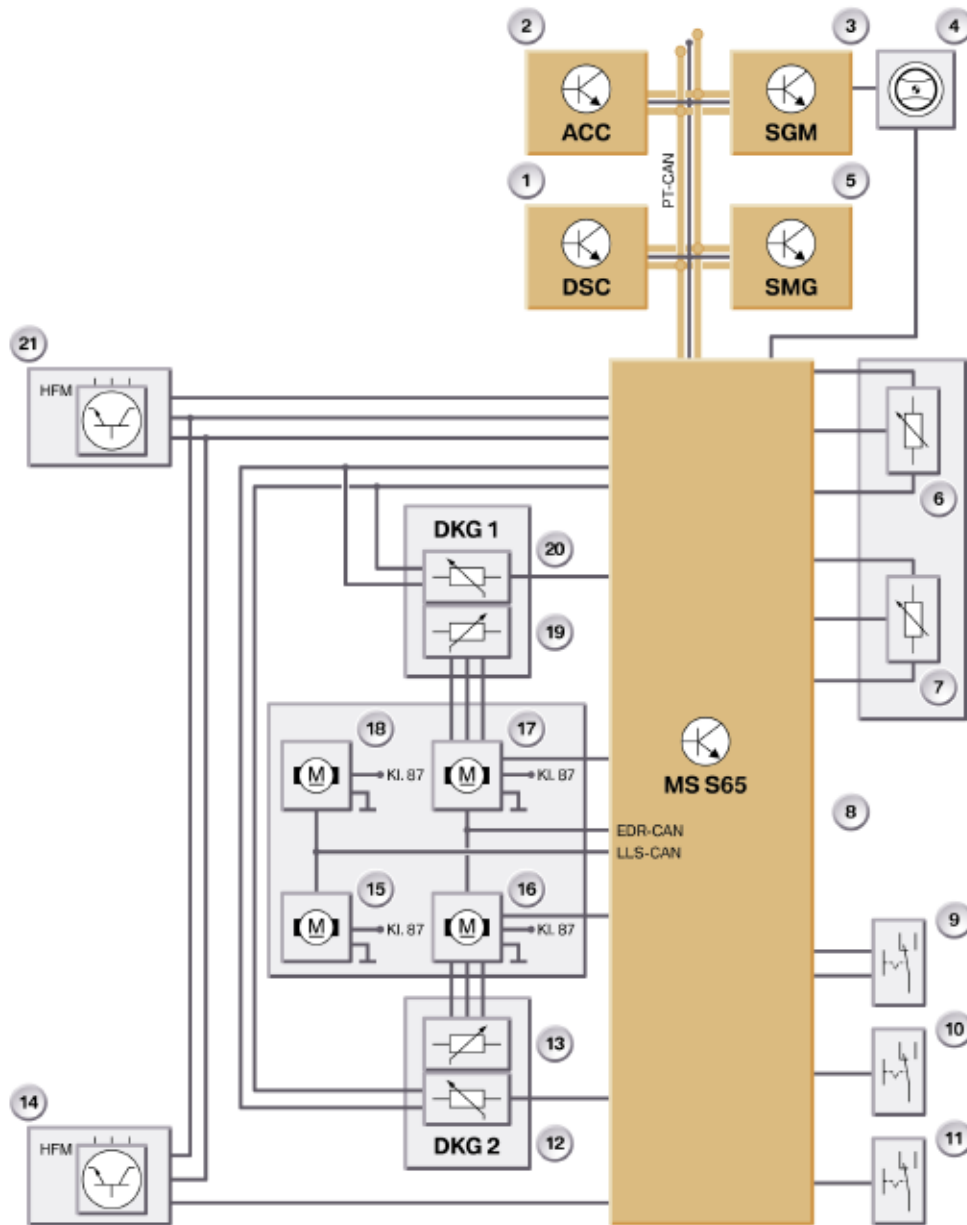
■ **LL-CAN**

There are two - 240 Ohm resistors, one in each idle actuator. The resistors are in parallel between LL-CAN-Hi and LL-CAN-Lo for a total resistance of 120 Ohms.

Idle System Schematic



Throttle System Overview



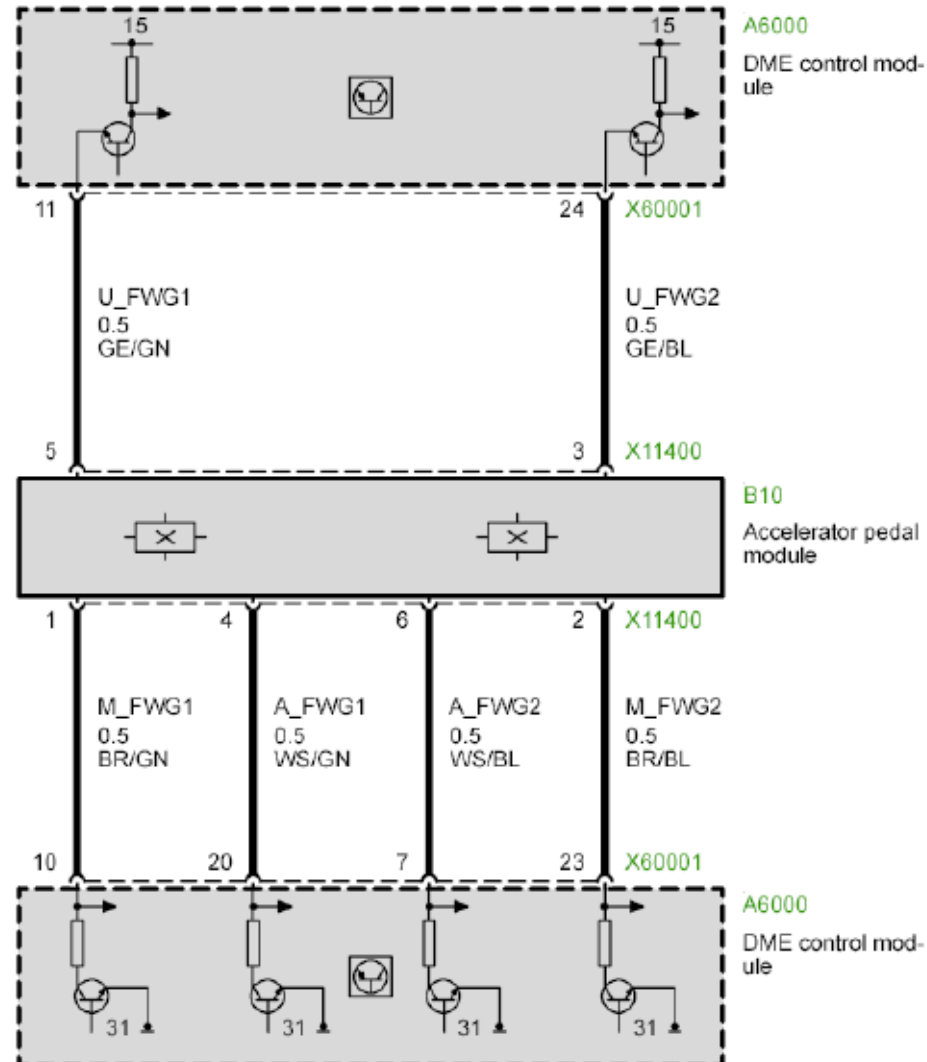
Index	Explanation
1	DSC
2	Active Cruise Control
3	SGM
4	Steering wheel
5	SMG
6	Accelerator pedal sensor
7	Accelerator pedal sensor
8	DME
9	Brake light switch
10	Clutch switch
11	Transmission switch, idle speed
12	Throttle valve sensor
13	Throttle valve sensor, inverted
14	HFM
15	Idle speed actuator
16	EDR
17	EDR
18	Idle speed actuator
19	Throttle valve sensor, inverted
20	Throttle valve sensor
21	HFM

Accelerator Pedal Module

The accelerator pedal module provides the input for the driver's request. The accelerator pedal module contains dual Hall sensors which the ECM monitors for plausibility. The ECM provides an independent voltage and ground supply for each hall sensor. Each Hall sensor is provided with 5 volts and ground. As the accelerator

pedal is moved from rest to full throttle, the sensors produce a variable voltage signal.

The Hall sensors are checked for plausibility. The voltage range of Hall sensor 1 is approximately .5 to 4.5 volts. Hall sensor 2 ranges from approximately .5 to 2.5 volts.



Hot Film Air Mass Meter (HFM)

The HFM is a Bosch type (HFM 5.0) with a CL bypass. There is one HFM for each bank. They are located in the intake silencers and incorporate the “plug-in” design.



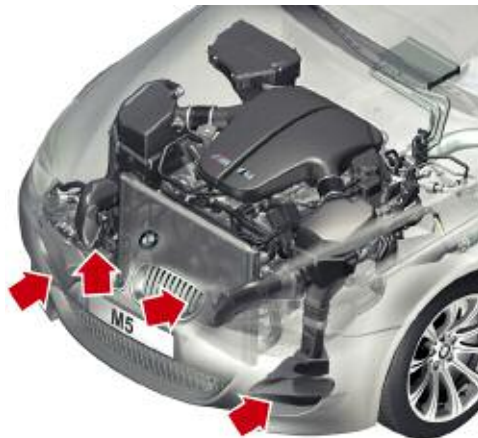
Intake Air Temperature Sensor

The intake air temperature sensor is integrated into the HFM housing. The sensor is an NTC type which receives 5 volt reference and ground from the ECM. The HFM sends a varying 5 volt analog signal to the ECM.

Intake Silencers

The air to the intake silencers (air filter housing), is drawn in via two pathways. One is from the area behind the kidney grille and the other from the large air inlets in the bumper.

The S85 requires 4 air ducts in order to achieve maximum output. For space reasons, there are 4 inlets to the air filter housings, rather than 2 large ones.



Crankcase Ventilation

The crankcase ventilation system on the S85 is used to separate liquid oil from crankcase gasses. The cyclone separators are integrated into the left and right intake plenums (1). The liquid oil from the separators is returned to the crankcase via two plastic hoses which are routed to the oil sump. The lines feed into two check valves behind cylinder 10.



There are also 2 check valves (one in each valve cover) which also allow any accumulated oil to drain back from the intake plenum housings.



Vacuum Pump

Although the S85 does not use Valvetronic, the assistance of an external vacuum pump is required under various operating conditions. In some operating modes, especially with a cold engine, when the catalyst heating function is active there is insufficient partial engine vacuum available for brake power assistance. There is also reduced engine vacuum when using “race track” (M-Dynamic) mode or when the vehicle is rolling with KL15 on and the engine off.

To make up for this limited vacuum period, there is a supplemental electric vacuum pump. The electric vacuum pump(2) is controlled via the ECM (DME). The pump is installed on the left in the engine compartment under the left microfilter housing.

The vacuum pump is designed as a vane-type pump. The prevailing partial vacuum is measured by a partial vacuum sensor.

The vacuum pump is switched on at -250 mbar and switched off at -600 mbar.

An external pressure sensor (1), signals the pressure difference from the brake booster compared to the ambient pressure from the internal ambient pressure sensor in the ECM (DME). (See diagram on the next page)

When vacuum is required, the ECM activates the relay which in turn then actuates the electric vacuum pump. The cut-in and cut-out thresholds are controlled as a function of the differential pressure and the vehicle speed.

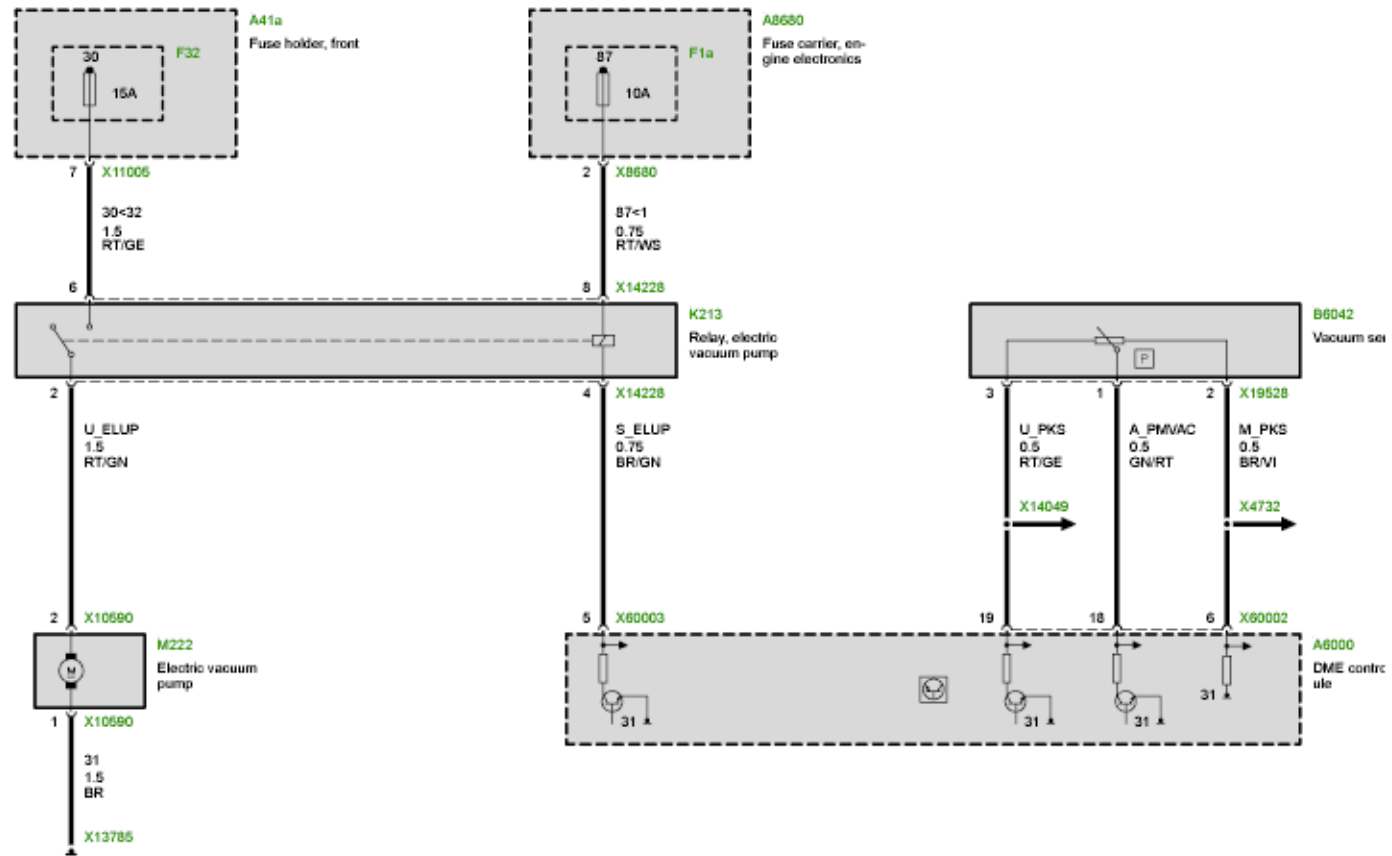
The software in the ECM is configured such that the correct vacuum is available in the brake booster under all driving conditions.

With relatively little vacuum in the brake booster, the engine must be running or the vehicle must be rolling with terminal 15 on in order to activate the electric vacuum pump.



Index	Explanation
1	External pressure switch
2	Electric vacuum pump

Vacuum pump relay circuit



A test module is provided in ISTA/GT1 for the electric vacuum pump. The differential pressure sensor on the brake booster is used for the purpose of monitoring the pump.

The plausibility is checked by the pressure difference between the vacuum and ambient pressure calculated internally in the ECM. It is evaluated and, in the case of fault, shown in the instrument cluster and displayed as a CC message (check control).

If the electric vacuum pump is found to be defective during the self-diagnosis procedure, the safety concept manager (SK manager) intervenes and shuts down cylinder bank II (Cylinders 6-10). The smaller opening cross section in the intake duct of cylinder bank 6-10 thus ensures adequate vacuum in the brake booster.

In the case of fault the safety concept manager triggers an "engine" symbol as well as a CC message (check control) "engine malfunction/power loss" in the instrument cluster.

■ Emergency Programs

The fault code "electric vacuum pump for Mastervac" (Mastervac = brake booster) is stored in the fault code memory in connection with the fault types "short to positive", "short to ground" and "line break". The following actions are initiated:

- Maximum torque 200 Nm
- Maximum engine speed 3500 rpm
- Maximum vehicle speed 150 km/h

The following actions are initiated in connection with the fault "pump not running":

- Maximum torque 100 Nm
- Maximum engine speed 2000 rpm
- Maximum vehicle speed 50 km/h

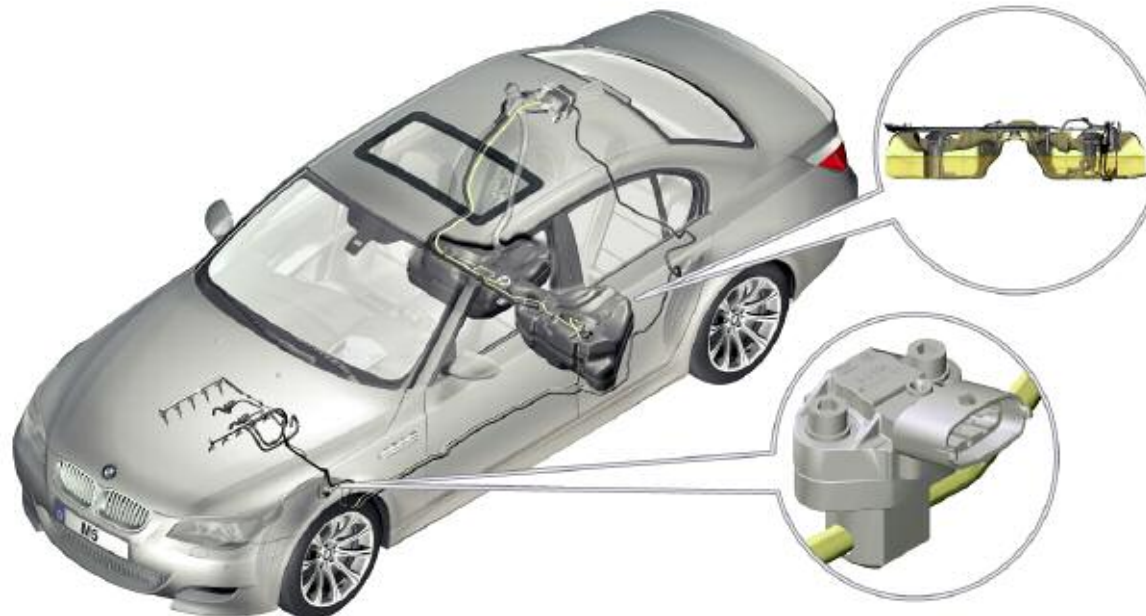
Fuel supply and management E60 M5

Fuel Supply and Management

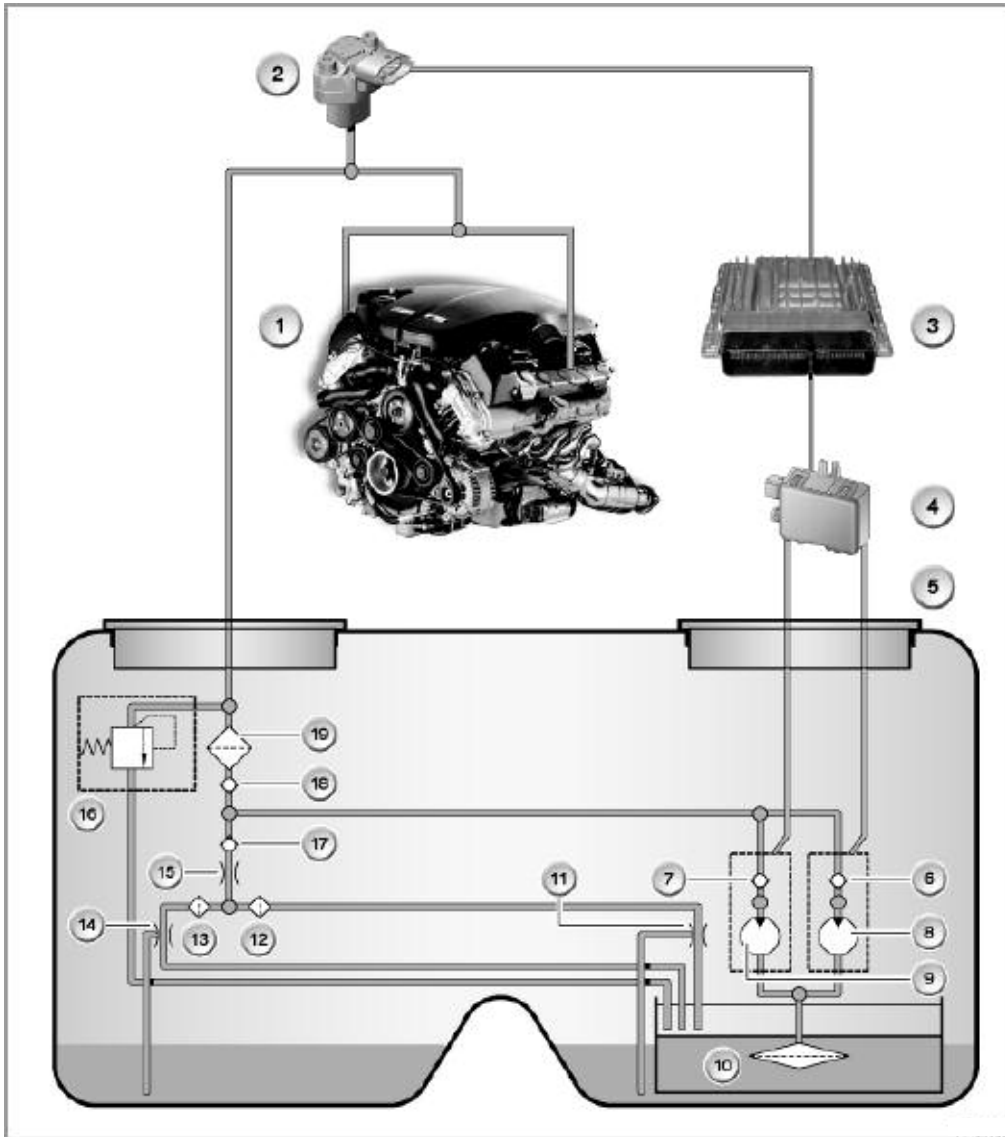
The fuel system on the S85 engine is a "demand-oriented" system which uses a variable fuel pressure delivery concept. The fuel pressure can be varied between 3 and 6 bar. This method of fuel delivery allows maximum delivery when needed, but also reduces HC losses from the fuel tank by keeping the overall fuel volume to the minimum. Additional benefits include increased service life of the fuel pump.

The fuel control circuit consists of the following components:

- Electric fuel pumps (2-EKP)
- EKP module
- Fuel tank with components and line system
- Fuel pressure sensor
- Digital motor electronics (DME) with the control logic



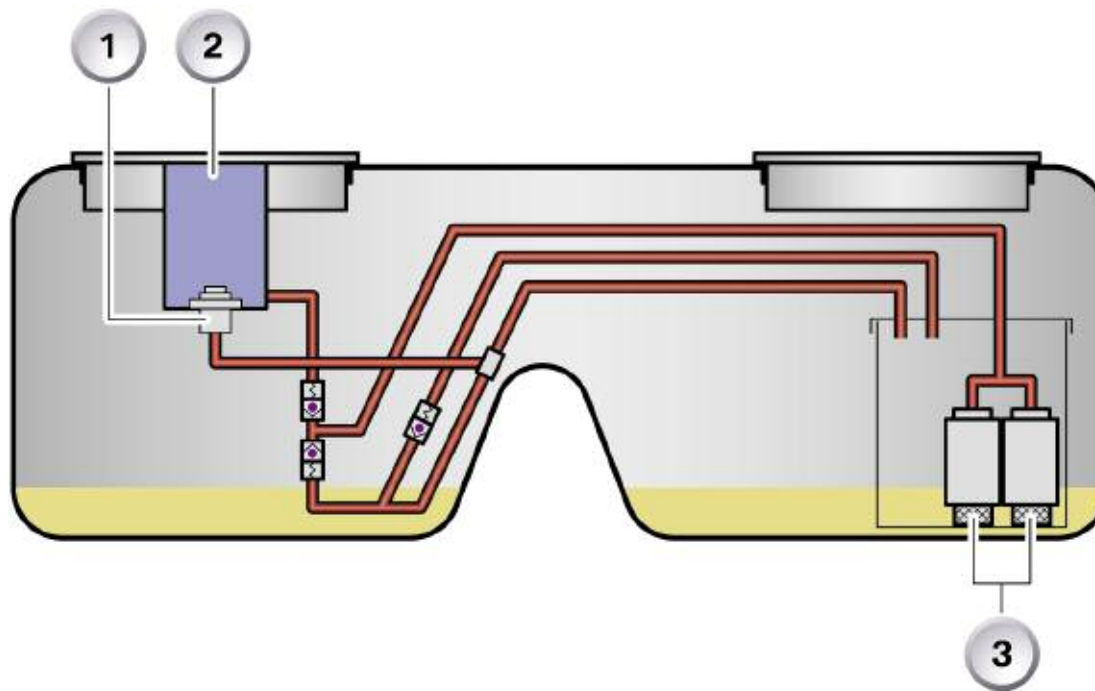
Fuel System Overview



Index	Explanation
1	S85 Engine
2	Fuel pressure sensor
3	Engine control unit (ECM)
4	EKP Control unit
5	Fuel tank
6	Check valve
7	Check valve
8	Fuel pump 1 (EKP1)
9	Fuel pump 2 (EKP2)
10	Surge chamber (with mesh screen)
11	Suction jet pump 1
12	Strainer
13	Strainer
14	Suction jet pump 2
15	Restrictor
16	Fuel pressure regulator
17	Check valve
18	Check valve
19	Fuel filter

Fuel Pumps

The fuel tank has been modified from the standard production E60 to accommodate two fuel pumps. Both pumps are a vane type and are located on the right-hand side of the fuel tank.

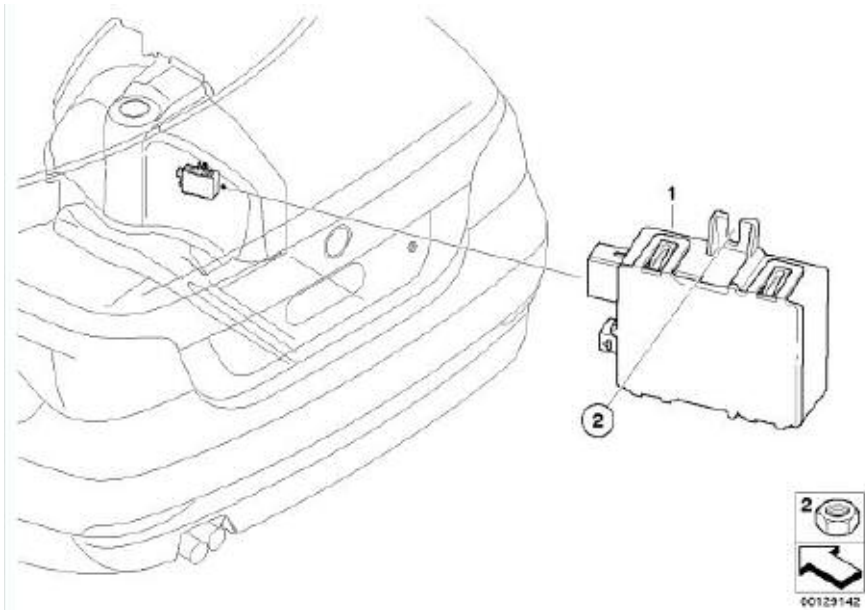


Index	Explanation	Index	Explanation
1	Fuel pressure regulator	3	Fuel pump 1 and 2 (EKP 1 and EKP 2)
2	Fuel filter		

EKP Module

The EKP module is located in the luggage compartment on the right side.

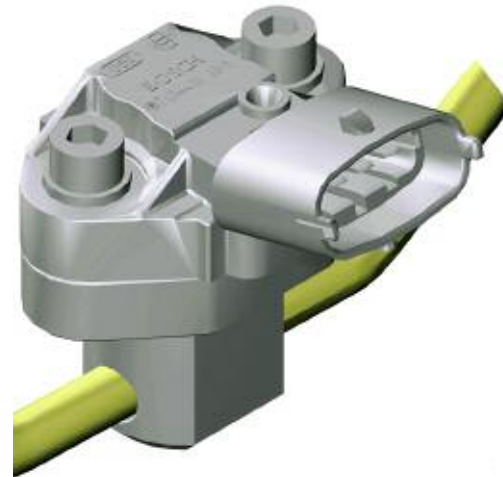
The output stage of the EKP module has been modified to accommodate two fuel pump output circuits and the associated control logic.



Fuel Pressure Sensor

The fuel pressure sensor is located in the front left wheel arch. The sensor is used to measure the current fuel pressure and to transfer the pressure value reading to the engine management.

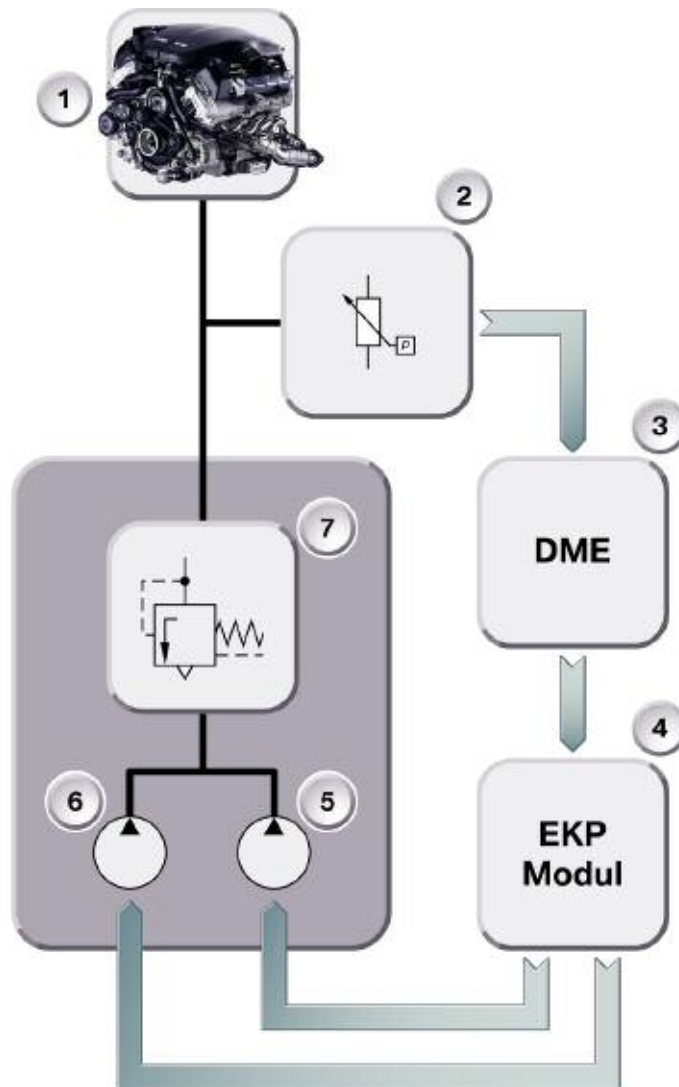
The fuel pressure sensor renders manual fuel pressure testing unnecessary. Fuel pressure values can now be displayed using the BMW diagnostic equipment.



Fuel System Operation

The ECM (DME) is responsible for the control of 2 in-tank fuel pumps which are connected to the fuel system in parallel. The first fuel pump (EKP1) covers the fuel required by the engine up to about 60%. EKP1 is operated via a variable duty cycle by the EKP control unit.

The fuel pressure is varied by the speed of the pump (not the mechanical fuel pressure regulator). The fuel pressure sensor is needed to provide the ECM with the proper information to provide adequate pressure control.



Index	Explanation
1	S85 Engine
2	Pressure sensor
3	ECM (DME)
4	EKP Control module
5	EKP 1
6	EKP 2
7	Fuel pressure regulator (6 bar)

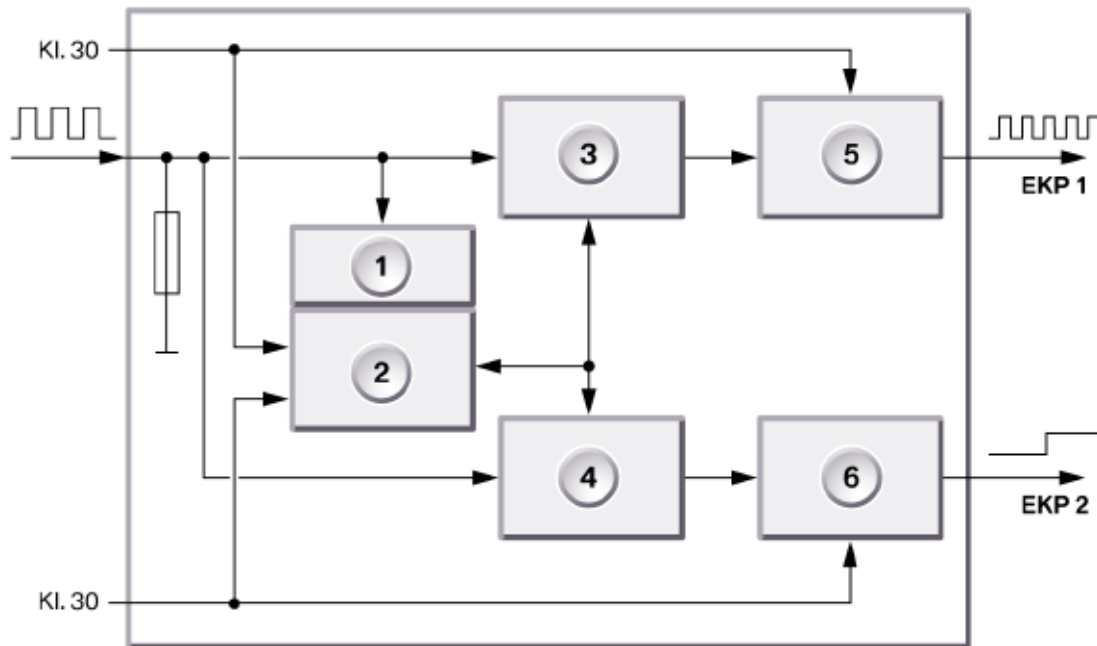
From approximately 5000 RPM (also load dependent), the second fuel pump (EKP2) is switched on at 100%. EKP 1 is also switched to 100%. At this point, the mechanical fuel pressure regulator is responsible for setting maximum fuel pressure to 6 bar.

The EKP module is controlled by the ECM over a single wire PWM interface. The pulse width of the signal dictates the delivery capacity of the electric fuel pump. The task of the EKP module is to clock the electric fuel pump (EKP) via the output stage with precisely this pulse duty factor. The deviation of the pulse duty factor between the input and output PWM signal must not be greater than 3%.

This tolerance applies over the entire service life of the EKP module. The second electric fuel pump EKP additionally cuts in on reaching a pulse duty factor of 100%.

■ Emergency Program

If faults are detected in the fuel supply system, the fuel system is run in emergency mode. At this point, both pumps are operated with 100% activation.



Index	Explanation
1	Activation
2	Power supply
3	Control logic EKP 1
4	Control logic EKP 2
5	Output stage EKP 1
6	Output stage EKP 2

Fuel Injectors

The injectors are mounted into machined bores located in the throttle housings. This design allows the injectors to be closely mounted to the intake valves.

The injectors are a compact design manufactured by Bosch with a resistance value of approximately 12 ohms each.

Power supply for the fuel injectors is from Terminal 87 of the fuel injector relay which is controlled by the CAS.



Fuel Rail

The fuel rail is a non-return design which does **NOT** include a service port for diagnosis. Fuel pressure is measured by the ECM via a fuel pressure sensor. The sensor is located in the driver's side front wheel arch.





Workshop Exercise - Fuel System

Using the ISTA or GT-1, obtain the diagnosis requests for the fuel system and locate the current fuel pressure data.

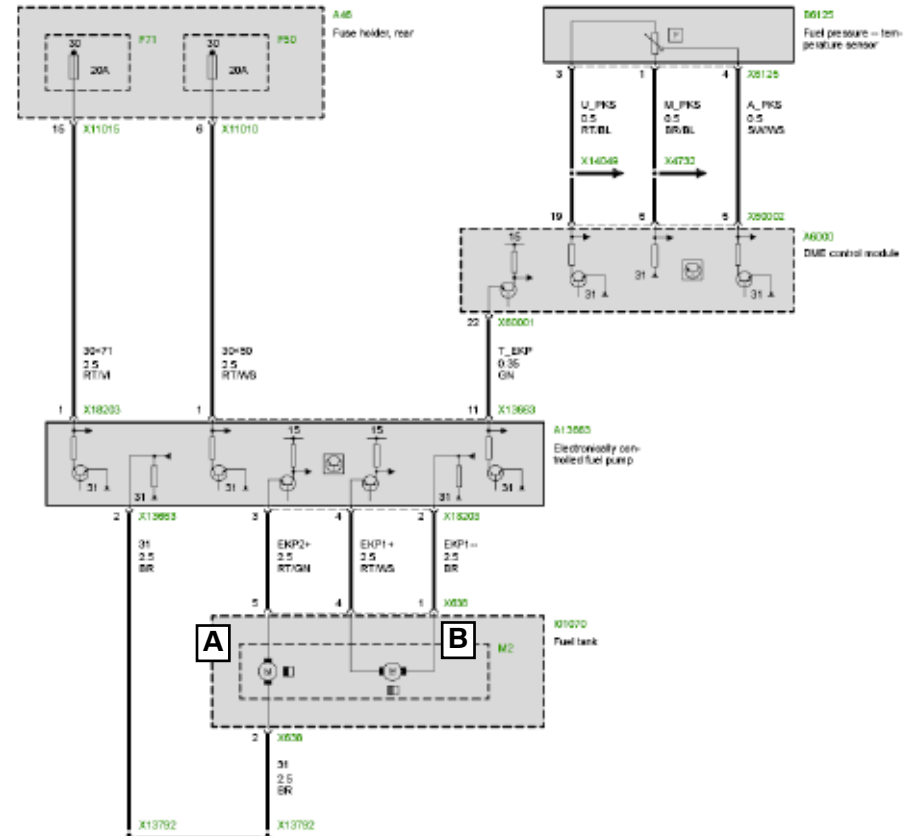
Complete the chart below with the requested information:

Operating condition	Fuel Pressure (bar)
Starting/cranking	
Idle	
Throttle blip > 5000 rpm	

Based on the schematic on the right, is it possible to code/program the EKP control unit? (Why or Why not)

Based on the schematic to the right, Identify the ON/Off fuel pump and the Variable PWM pump.

E60 M5 Fuel Pump Diagram





Workshop Exercise - Fuel System

Monitor the fuel pump activation line (T_EKP) between the ECM and EKP module using an oscilloscope and measuring system functions.

Complete the chart below with the requested information:

Operating condition	Voltage	Frequency	Duty Cycle
Starting/cranking			
Idle			
Throttle blip > 5000 rpm			

What happens to the fuel pressure when the engine is under load?

List the part number of the test cable used for the EKP module:

Monitor voltage on the fuel pump voltage supply lines to pumps 1 and 2.

Measure at the EKP module located in the luggage compartment.

Use the MIN/MAX function to assist in your measurement.

Complete the chart below by filling in the requested information:

Operating condition	Voltage Pump 1	Voltage Pump 2	Frequency	Duty Cycle
Starting/cranking				
Idle				
Throttle blip > 5000 rpm				

NOTES

PAGE

Ignition Management

The ignition system on the MS-S65 engine management uses several inputs to control ignition functions. There are some changes as compared to previous BMW engine management systems. The knock sensors have been eliminated in favor of a new “ionic current” measuring system. The new “ionic current” monitoring system is also capable of detecting misfires as well.

Ignition Coil

As with most recent ignition coil designs, the “pencil” or “rod” type ignition coils are used in the S85 engine.

The ignition coils are manufactured by Bremi or Bosch. The ignition coils are triggered by the ionic current control units based on signals from the ECM.

The Zener diode in the secondary winding has been eliminated to allow ionic current measurement.



Spark Plugs

With the introduction of the new ionic current monitoring technology, the spark plugs for the S85 have been specially manufactured by NGK.

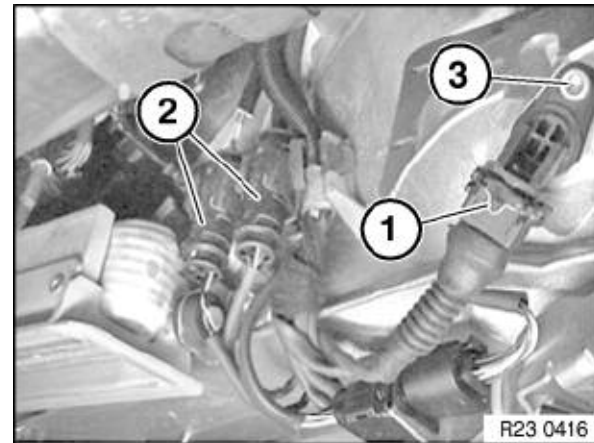
The new (LKR8AP) spark plug uses a two-prong ground electrode, with a center electrode which has a laser welded platinum ring. The plug also features a very long reach (26.5mm) and a 12 mm thread.

The spark plug now carries out two functions:

- To provide a gap between the spark plug electrodes
- To act as a sensor for ionic current monitoring

Crankshaft Position Sensor

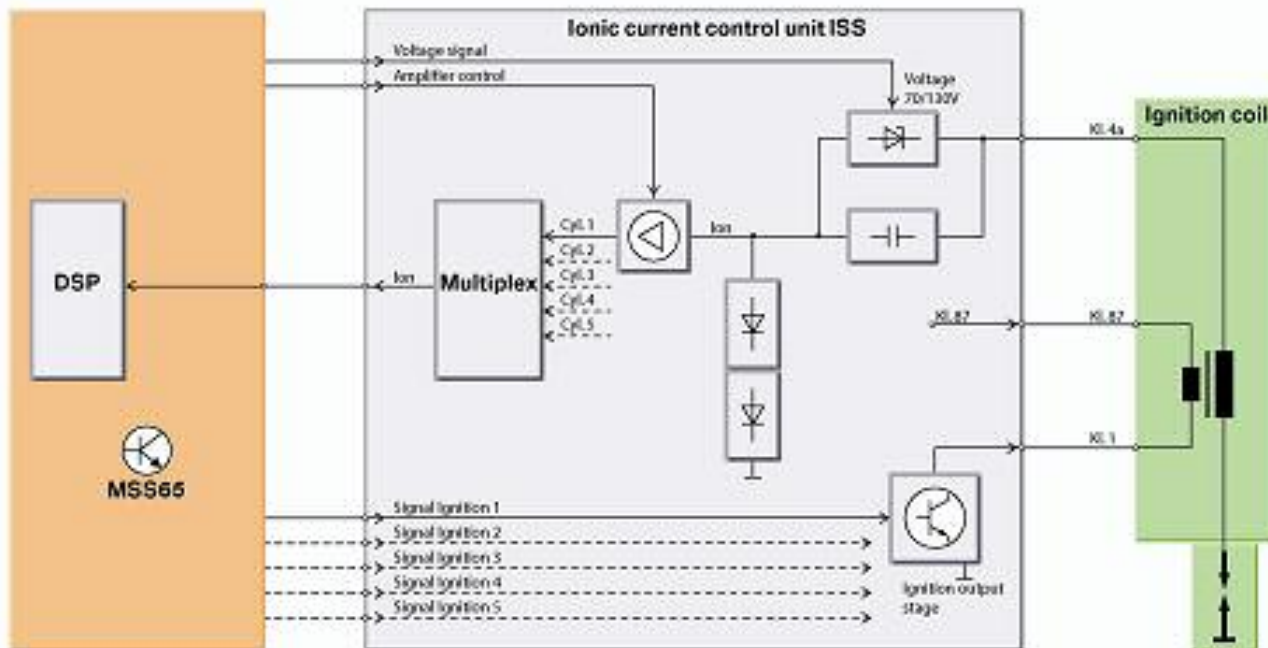
This sensor provides the crankshaft position and engine speed (RPM) signal to the ECM for Fuel Pump and Injector operation. This is a “Hall Effect” type sensor mounted on the transmission bell housing (3). The impulse wheel is mounted on the outer circumference of the flywheel. The impulse wheel contains 58 teeth with a gap of two missing teeth. The gap of two missing teeth provides a reference point that the ECM recognizes as crankshaft position.



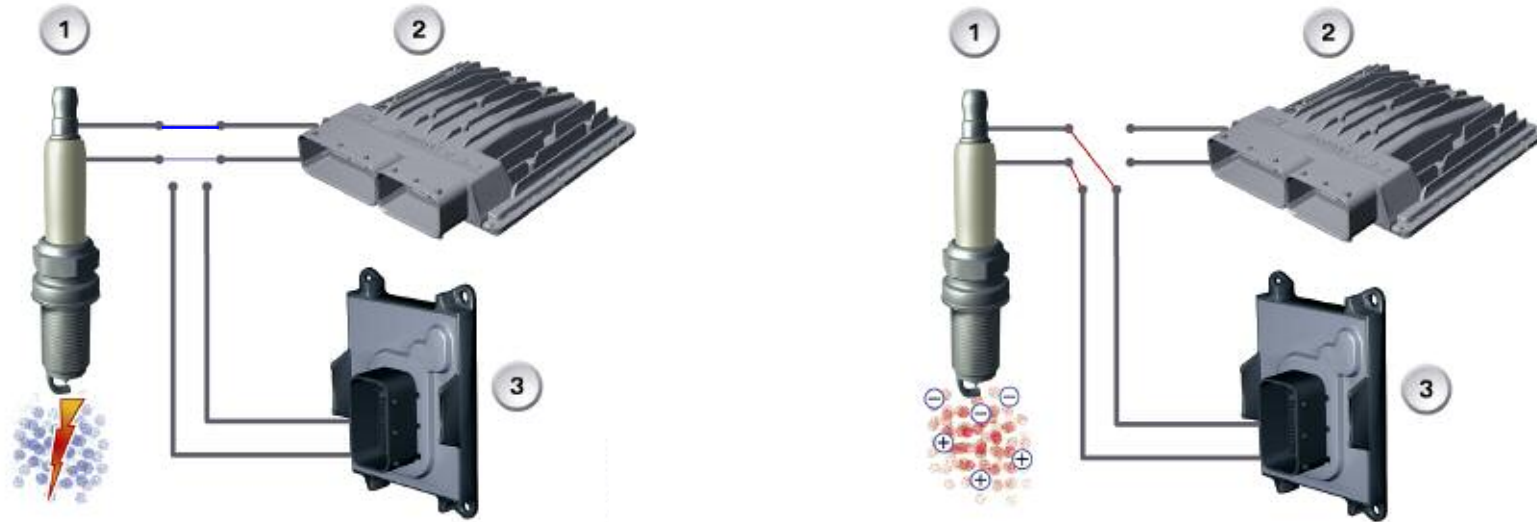
Ionic Current Control Units

There are 2 ionic current control units which are located at the front of the engine on top of the respective cylinder head cover. These units are manufactured by Helbako and are responsible for control of the ignition coils via signals from the ECM (DME).

In addition to ignition coil control, the ionic current control unit is used to measure ionic current during the combustion period (after ignition). These measurements are used by the engine management to monitor knock as well as misfiring.



Ionic Current Overview



Index	Explanation
1	Spark plugs
2	Engine control unit
3	Ionic current control unit

Ionic Current Measurement

Ionic current monitoring technology holds many benefits for the detection of misfires and engine knock. Currently, misfires are detected by monitoring the crankshaft for speed fluctuations. This method is limited on very smooth running engines, particularly on those with more than 8-cylinders.

Ionic current technology makes it possible to monitor both misfires as well as engine knock. This is done mostly with existing hardware. The spark plug is now assigned a dual role. In addition to supplying the air gap which makes ignition possible, the spark plug is now used as a “current probe” to measure ionization during combustion.

Once the ignition phase has ended, the combustion phase begins with a uniform flame front across the combustion chamber. During the combustion period, heat and pressure ionize particles in the combustion chamber in the area of the spark plug electrodes.

These ions can be measured to give an indication of cylinder pressure. The cylinder pressure peaks can be interpreted to show combustion quality.

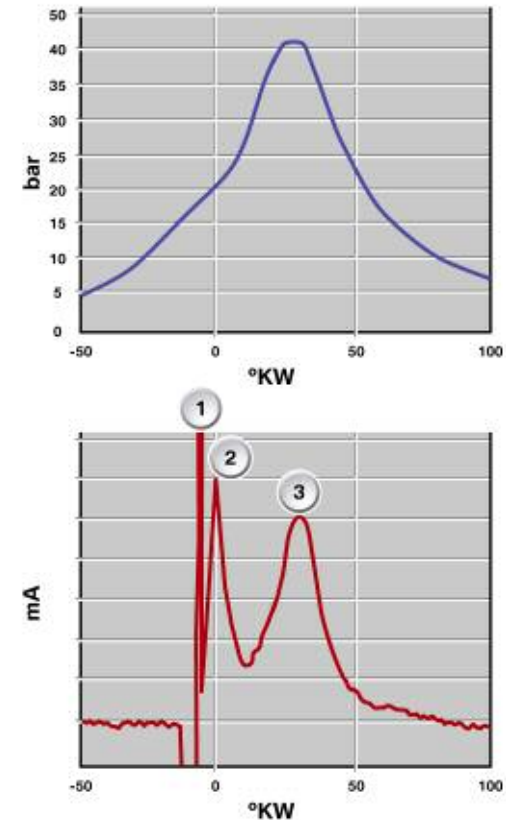
Ionic current progression is directly dependent on the cylinder pressure and the ions in the cylinder. In other words, the **quantity** of ions is dependent upon the **quality** of combustion.

The ionic current is measured after ignition occurs. A low voltage is applied between the electrodes of the spark plug immediately after the end of the ignition spark and the resulting current (ionic current) is measured. The ionic current is measured and evaluated by the ionic current control unit and the ECM (DME).

The combustion progression in the combustion chamber can be represented by the combustion chamber or cylinder pressure curve.

As a general rule :

- Poor combustion = low cylinder pressure
- Good combustion = high cylinder pressure

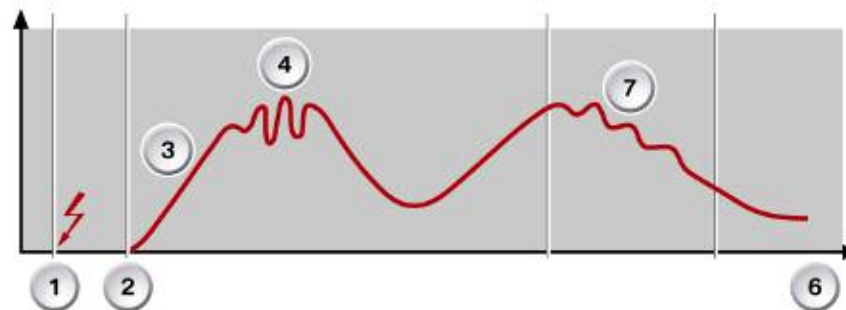
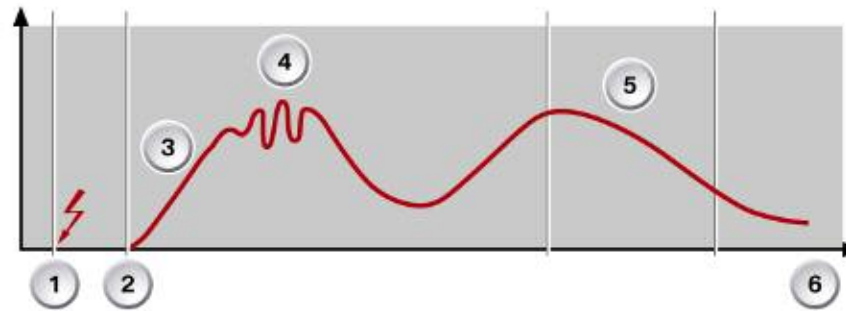


Index	Explanation
1	Ionic current at maximum by induction of ignition coil
2	Ionic current maximum due to ignition (flame front directly at spark plug electrode)
3	The ionic current progression curve is a function of the pressure curve

During various combustion events, free ions additionally split off or separate due to abnormal pressure peaks that occur in the combustion chamber when knocking or detonation occurs. This results in a change in the ionic current progression (curve).

The ionic current is measured and evaluated in the ionic current control unit. The ECM will make necessary corrections to control knocking. This method of knock detection eliminates the need for knock sensors. Also, the possibility for erroneous knock signals is eliminated.

Ionic Current Knock Detection



Index	Explanation	Index	Explanation
1	Firing Point	5	No knocking
2	End of Ignition	6	Time
3	Ionic Current	7	Knocking
4	Flame front signal		



Workshop Exercise - Ionic Current Ignition System

Perform the following ignition tests on an instructor assigned E60 M5 training vehicle.

Using MFK2, a 60 pin breakout box and appropriate Y cable, obtain the **primary ignition** pattern for cylinder #3.

Sketch pattern below:

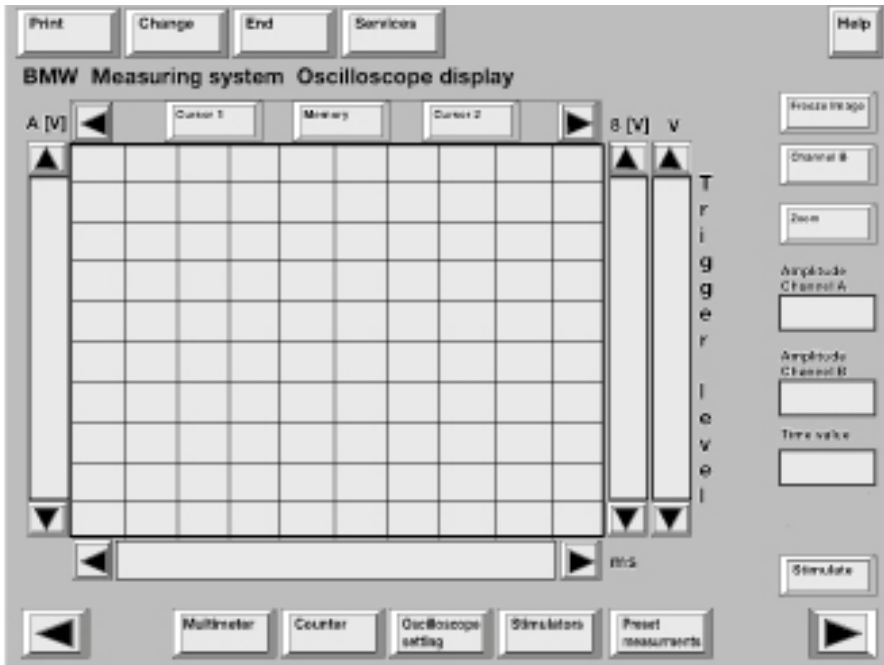
What is the part number of the necessary Y cable to connect to the Ionic Current Control Unit?

Is there anything unique regarding the primary ignition pattern?

What is the resistance of the primary winding of the ignition coil?

Where are the “final stage” transistors located?

Notes:



Note the proper scope settings to capture the signal below.

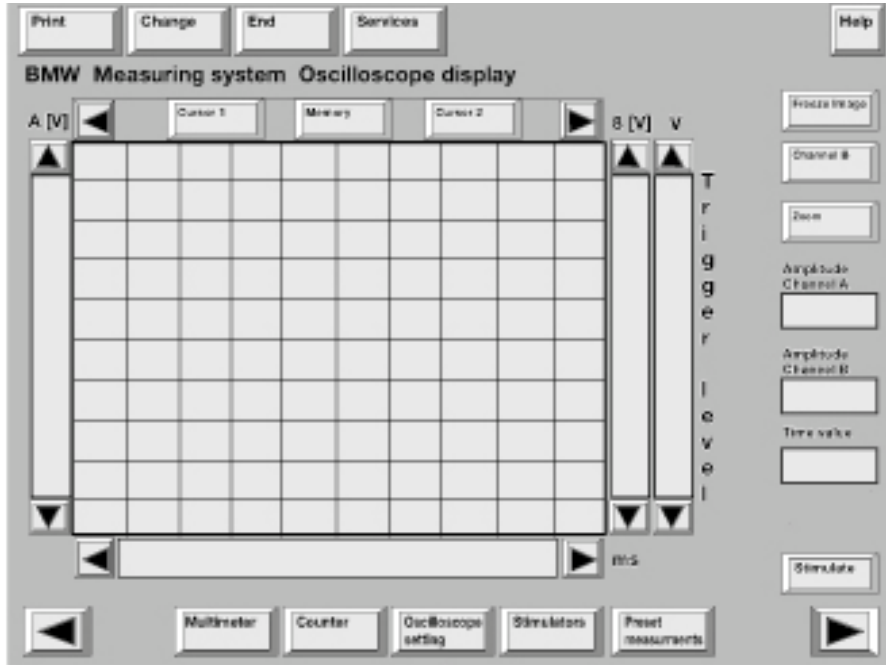
Note the proper BOB pins to probe to capture the signal below.



Workshop Exercise - Ionic Current Ignition System

Proceed and check the **secondary ignition** pattern for cylinder #3.

Sketch pattern below:



Note the proper scope settings to capture the signal below.

What is the part number of the special tool used for this measurement?

Is there anything unique regarding the secondary ignition pattern?

Measure the resistance of the secondary winding of the ignition coil:

What is the observed resistance?

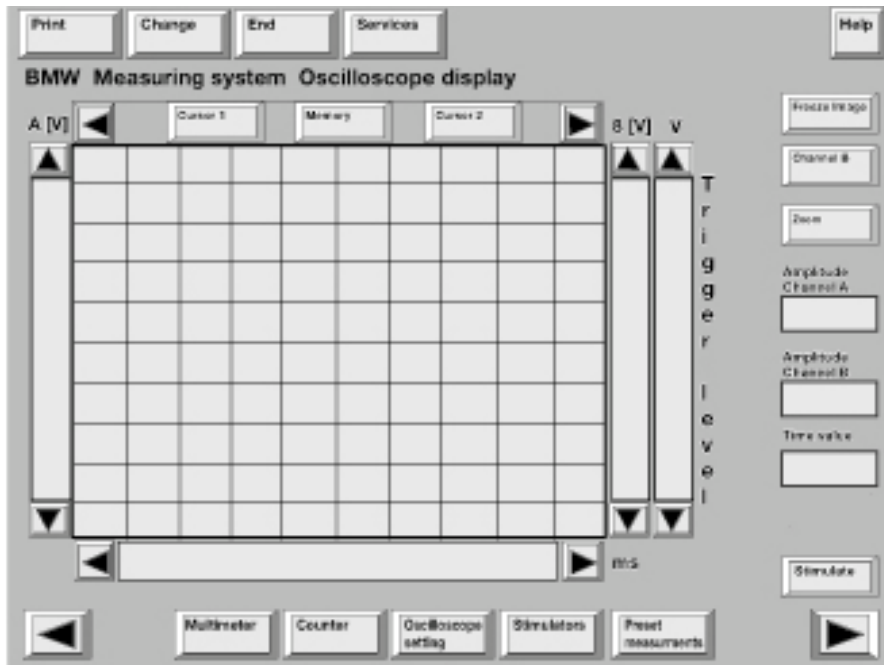
What is the purpose of the ignition coil modifications?



Workshop Exercise - Ionic Current Ignition System

Connect breakout box to ionic current control unit. Using an ETM for reference, monitor the ignition **coil control line** between the ECM and the ionic current control unit.

Sketch pattern below:



Note the proper scope settings to capture the signal below.

Note the proper BOB pins to probe to capture the signal below.

What is the purpose of the “ignition control line”?

What happens to this signal when the RPM is increased?

Notes:



Workshop Exercise - Ionic Current Ignition System

Obtain the scope pattern for the ionic voltage signal (between the coil and ionic current control unit).

Sketch pattern below.

What is the maximum observed voltage?

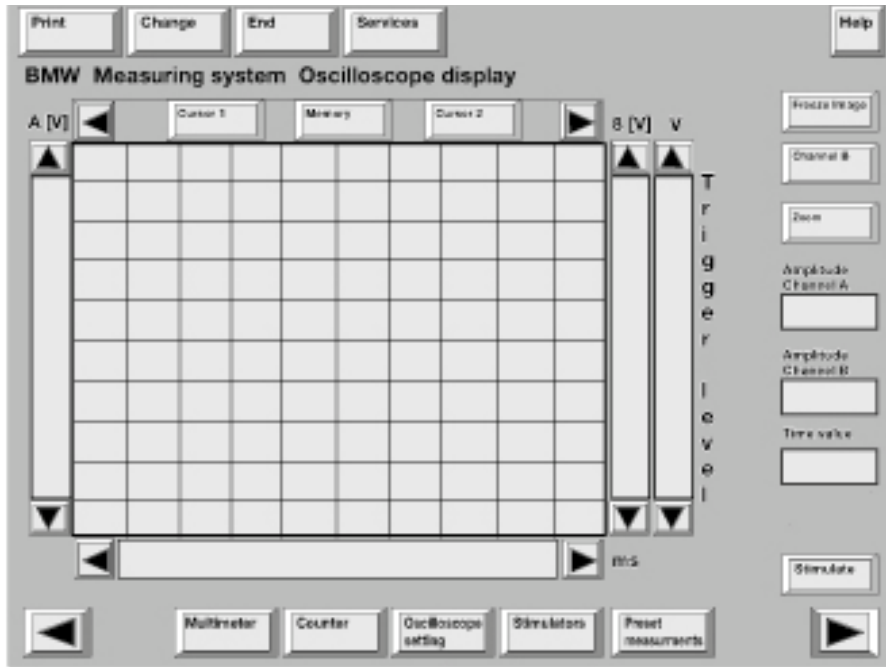
What does this signal represent?

What modifications have been made to the coil to allow this circuit to be possible?

What would occur if this signal were interrupted?

Note the proper BOB pins to probe to capture the signal below.

Note the proper scope settings to capture the signal below.





Workshop Exercise - Ionic Current Ignition System

Obtain the scope pattern for the **return “feed back” signal** (between the ionic current control unit and the DME).

Sketch pattern below.

Vary the oscilloscope frequency setting and note the average signal amplitude.

Can a distinction of an individual cylinder operation be identified?

Disable proper combustion by creating a rich or lean mixture (remove pump #1 control circuit).

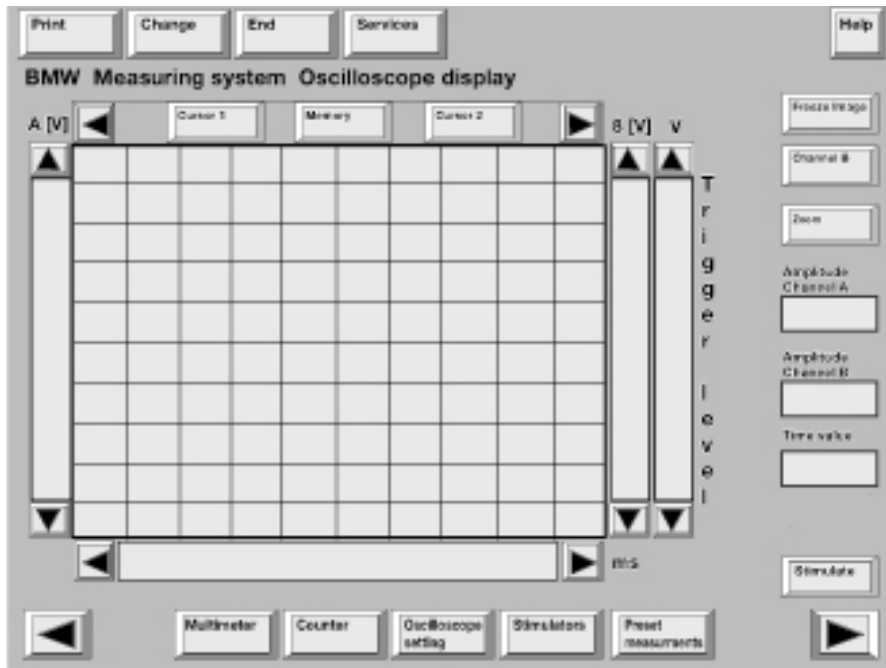
What happens to the signal?

What “relevant” faults are created as a result of this condition?

Momentarily disable the ignition on an individual cylinder.

Note the changes if any to the signal:

What “relevant” faults are created as a result of this condition?



Note the proper BOB pins to probe to capture the signal below.

Note the proper scope settings to capture at least 10 signals.

Emission Management

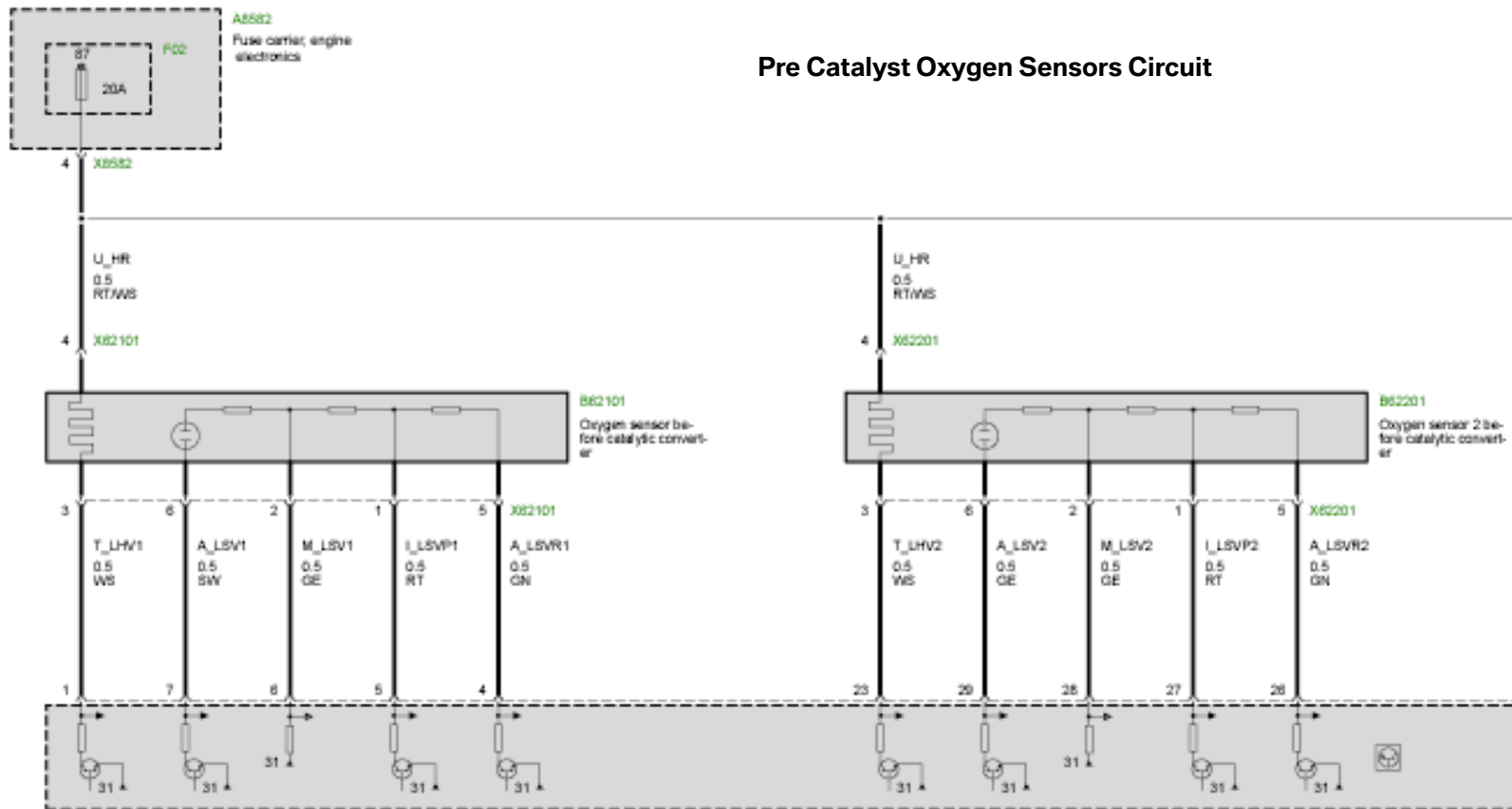
The S85 engine with MS_S65 engine management complies with LEV II standards.

Bosch LSU Oxygen Sensor

A “wide-band planar” oxygen sensor used on the S85. The new Bosch LSU 4.9 sensor is carried over from the N62TU and N52 engines. Compared with the LSU 4.2 oxygen sensor previously used, the LSU sensor is twice as fast. Full operational readiness is achieved after 10 seconds (LSU 4.2 20 seconds).

This rapid starting capability is made possible by the use of a smaller ceramic element. The outer dimensions of the sensor remain unchanged.

The previous opening for the supply of ambient air has been eliminated. The new sensor differs from the LSU 4.2 in that a porous layer which is permeable by air is used instead of a reference air channel. The ambient air is directed to the element via the sensor wiring.



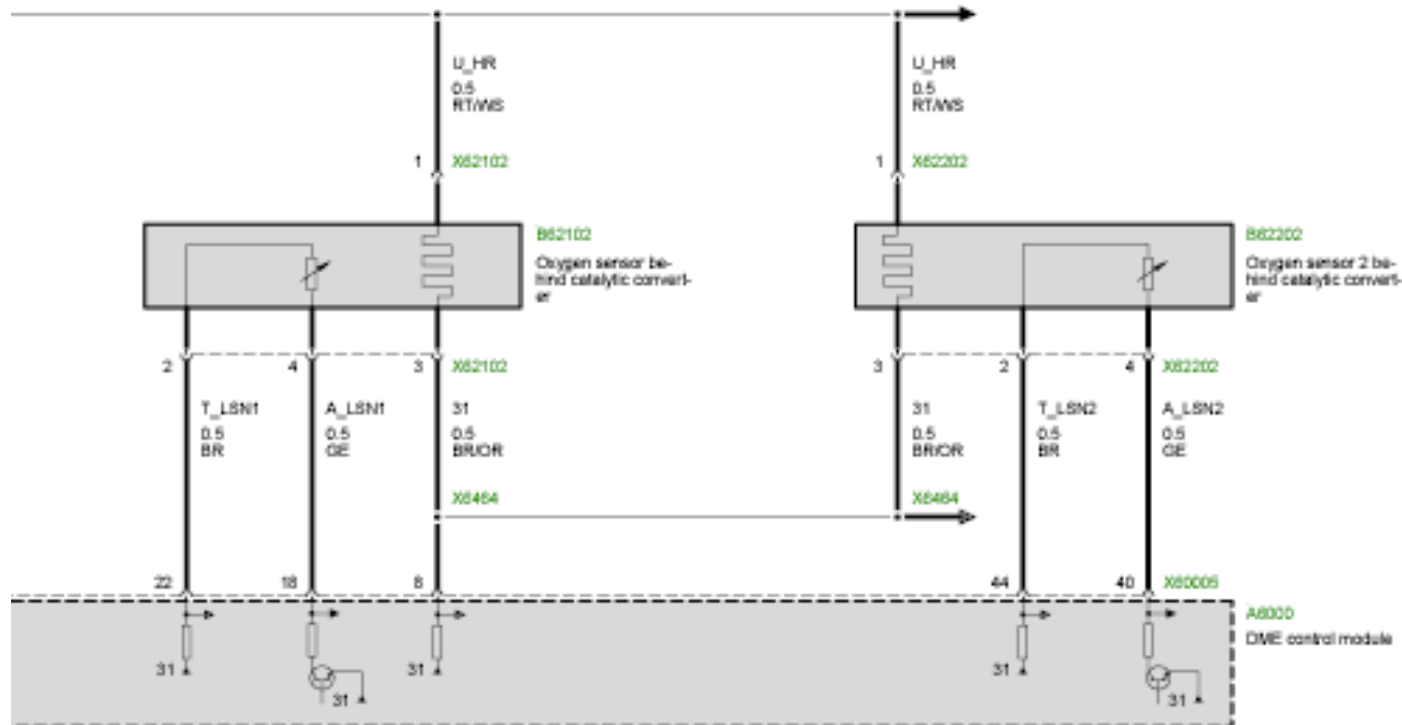
Post Catalyst Oxygen Sensors

The post catalyst oxygen sensors are the Bosch LSF 4.2 type. They operate similarly to the previous LSH 25 sensors. The voltage range is .10 to 1.0 volts.

The new planar 4.2 sensors offer:

- Fast light-off (ready for control <10 s)
- Wide operating temperature range
- Stable control characteristic
- Improved exhaust gas values

Post Catalyst Oxygen Sensors



Exhaust Gas Temperature Sensor

The exhaust temperature sensors are designed as NTC measuring elements. The sensor can detect temperatures of up to approximately 1,200°C. Two exhaust-gas temperature sensors (one on each cylinder bank of the S85) provide exhaust-gas temperature readings to the DME (ECM) to protect the catalytic converter.

From 03/2006, the signals from the exhaust gas temperature sensors in DME are no longer used. However, the exhaust gas temperature sensors were still fitted until 09/2006.

The signals were replaced by calculated exhaust gas temperature values. The exhaust gas temperatures are also no longer diagnosed in the DME.

Note: From 03/2006, the signals from the exhaust gas temperature sensors are no longer monitored.

Secondary Air System

Injecting ambient air into the exhaust stream after a cold engine start reduces the warm up time of the catalyts and reduces HC and CO emissions. The ECM controls and monitors the Secondary Air Injection.

An Electric Secondary Air Pump and Air Injection Valve direct fresh air through an internal channel in the cylinder head into the exhaust ports. The Air Injection Valve is opened by air pressure (from the pump) and is closed by an internal spring.

The relay for the secondary air pump is located in the E-box.

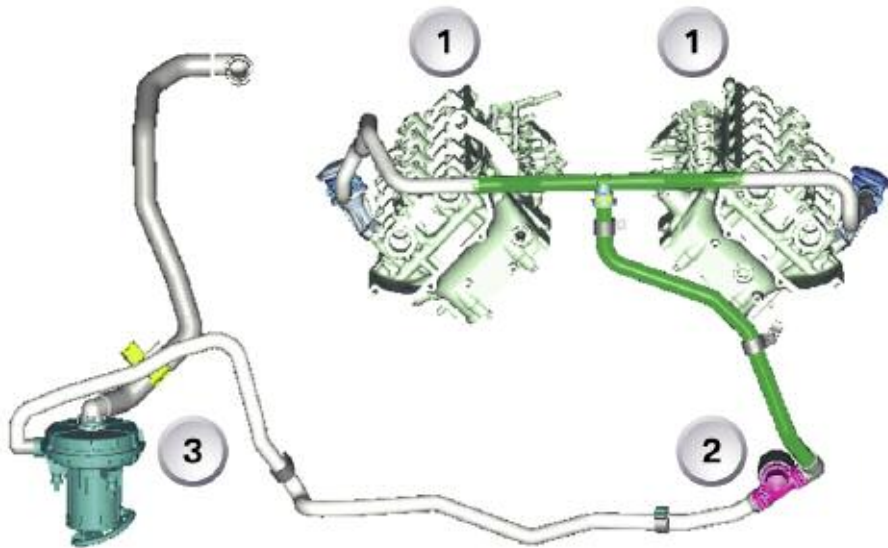
The secondary air pump is equipped with an additional intake hose to accommodate a secondary air filter with the mini HFM. The mini HFM is secured in the secondary air filter with two screws.

■ Mini Hot Film Air Mass Sensor (HFM)

A compact mini hot film air mass sensor (HFM manufactured by Siemens) is used in the secondary air system for the S85 engine in the M5 and M6.

The mini HFM detects the air mass supplied by the secondary-air pump. This function monitors the secondary air system for OBD compliance.

When the mini HFM detects no air mass or insufficient air mass, a fault is stored in the ECM and the Malfunction Indicator Light (MIL) is activated. The mini HFM has a compact pipe shaped design with O-ring connections.



Index	Explanation
1	Check Valves
2	Hose Junction
3	Secondary air pump

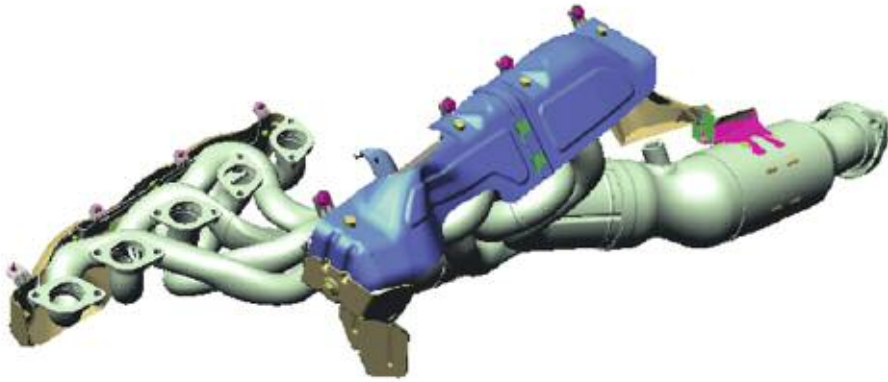


Mini Hot Film Air Mass Sensor (HFM)

Exhaust Manifold

The tubular stainless steel exhaust manifolds contain the familiar “near engine” catalytic converters.

The manifolds also provide the mounting for the pre and post catalyst oxygen sensors. The manifold also has provisions for the exhaust gas temperature sensor.



On-Board Refueling Vapor Recovery

The ORVR system on the M5 is identical to the production E60. This system recovers and stores hydrocarbon fuel vapor that was previously released during refueling. Non ORVR vehicles vent fuel vapors from the tank venting line back to the filler neck and in many states reclaimed by a vacuum receiver on the filling station’s fuel pump nozzle.

When refueling an ORVR equipped vehicle, the pressure of the fuel entering the tank forces the hydrocarbon vapors through the larger tank vent line to the liquid / vapor separator, through the rollover valve and into the charcoal canister. The HC is stored in the charcoal canister, and the system can then “breathe” through the DM-TL and the air filter. The vent line to the filler neck is smaller, but still necessary for checking the filler cap/neck during Evaporative Leak Testing.

Charcoal Canister

As the hydrocarbon vapors enter the canister, they will be absorbed by the active carbon.

The remaining air will be vented to the atmosphere through the end of the canister, DM-TL and filter, allowing the fuel tank to “breathe”.

When the engine is running, the canister is "purged" using intake manifold vacuum to draw air through the canister which extracts the HC vapors into the combustion chamber.

The Carbon Canister with DM-TL and air filter are located at the behind the right rear wheel.



Charcoal Canister view, behind the right rear wheel.

Evaporative Emission Valve (Purge Valve)

This ECM controlled solenoid valve regulates the purge flow from the Carbon Canister into the intake manifold. The ECM Relay provides operating voltage, and the ECM controls the valve by regulating the ground circuit. The valve is powered open and closed by an internal spring.

If the Evaporative Emission Valve circuit is defective, a fault code will be set and the “Malfunction Indicator Light” will illuminate when the OBD II criteria is achieved.

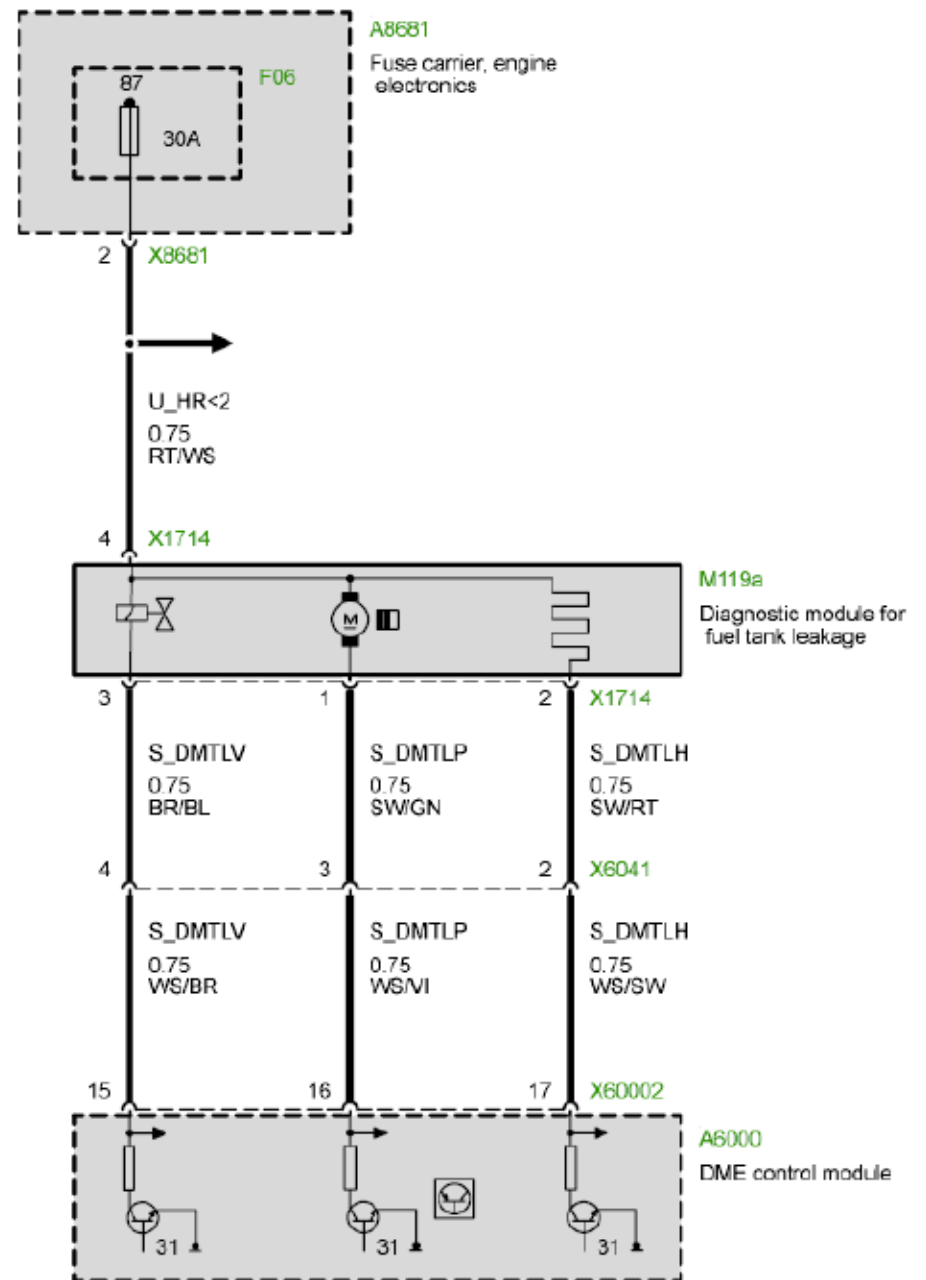
If the valve is “mechanically” defective, a driveability complaint could be encountered and a mixture related fault code will be set.

Evaporative Leakage Detection (DM-TL)

This component ensures accurate fuel system leak detection for leaks as small as 0.5 mm by slightly pressurizing the fuel tank and evaporative components. The DM-TL pump contains an integral DC motor which is activated directly by the ECM. The ECM monitors the pump motor operating current as the measurement for detecting leaks.

The pump also contains an ECM controlled change over valve that is energized closed during a Leak Diagnosis test. The change over valve is open during all other periods of operation allowing the fuel system to “breathe” through the inlet filter. The DM-TL pump is located behind the right rear wheel attached to the Carbon Canister.

To prevent condensation buildup in the DM-TL pump, a heating element is integrated into the housing of the pump. The heating element is ground controlled by the ECM.



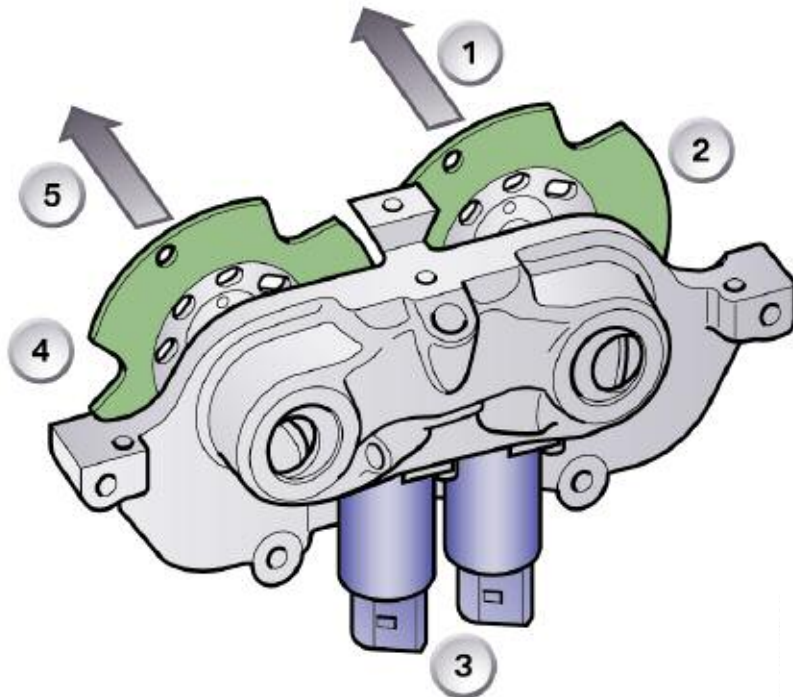
Performance Controls

VANOS

The VANOS used on the S85 is the “high-pressure” Bi-VANOS designed specifically for motorsport applications. The system is designed to allow for rapid and accurate camshaft timing changes. This is made possible due to a very high operating pressure. The operating pressure in this VANOS system is 115 bar.

The VANOS system of the S85 consists of the following components:

- Two VANOS actuating units (one for each bank)
- Two sets of VANOS transmissions (one set for each bank)



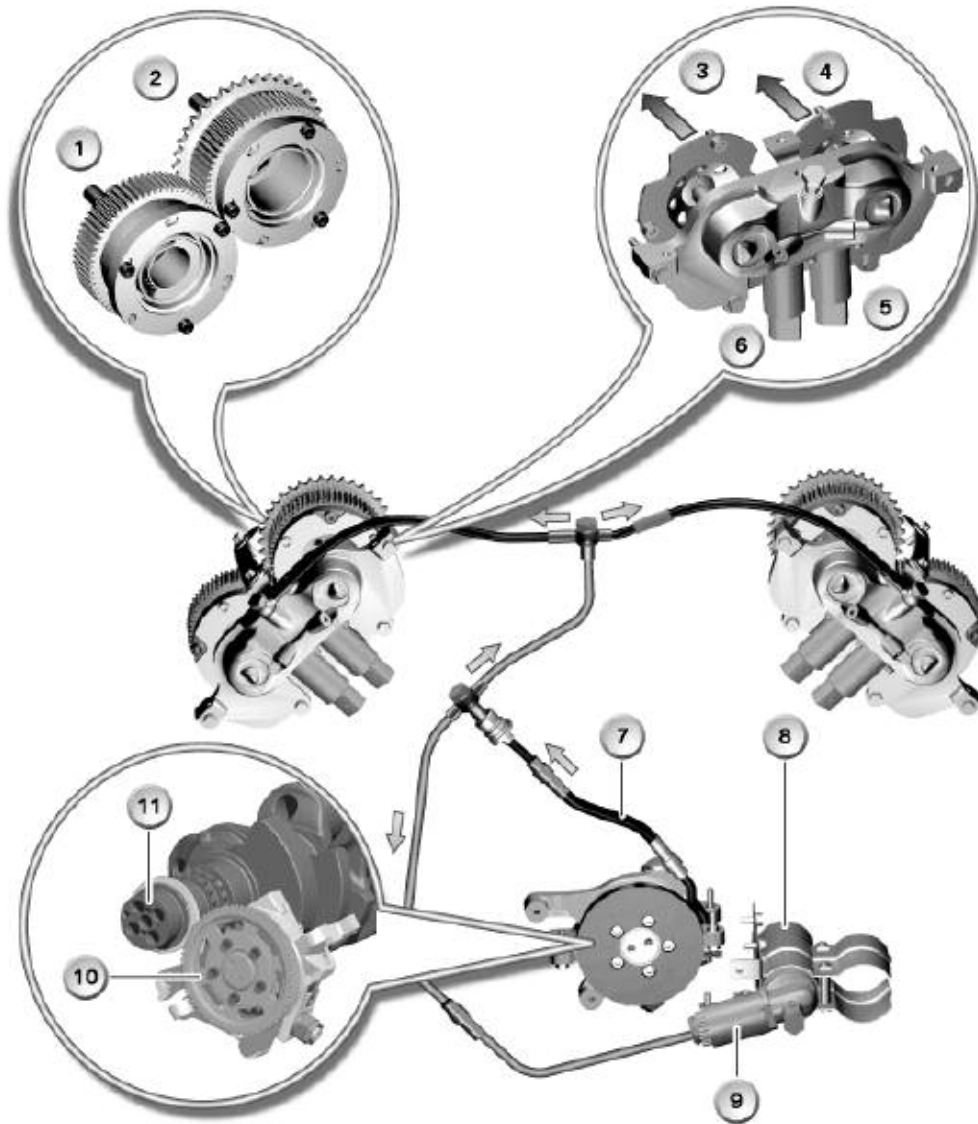
- High pressure radial piston pump
- Pressure accumulator with solenoid valve
- High pressure lines

VANOS Actuating Unit

The actuating unit consists of the adjustment pistons and solenoid valves. The adjustment pistons provide axial movement when oil pressure is applied. The solenoid valves, which are controlled by the ECM, direct oil flow to control piston movement.

Index	Explanation
1	Adjustment direction, advance
2	Intake (adjustment piston)
3	Solenoid valves
4	Exhaust
5	Adjustment direction, retard

VANOS Overview



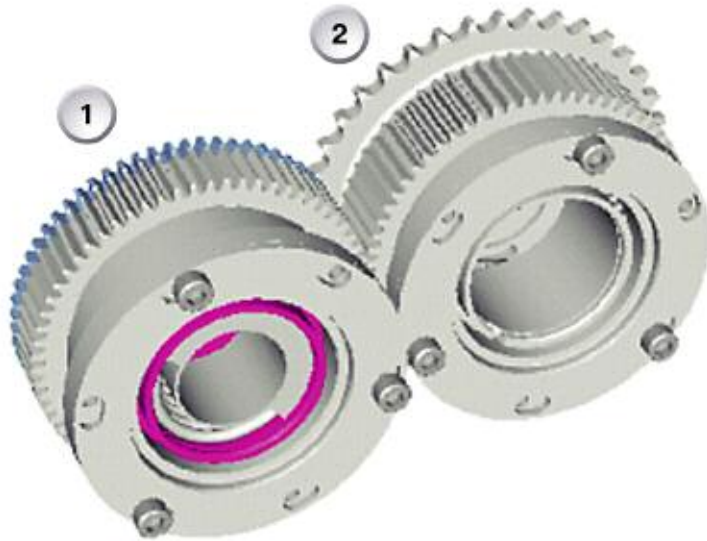
Index	Explanation
1	VANOS transmission (exhaust cam)
2	VANOS transmission (intake cam)
3	“Retard” adjustment, exhaust camshaft
4	“Advance” adjustment, intake camshaft
5	VANOS solenoid valve, intake
6	VANOS solenoid valve, exhaust
7	High pressure line for oil pump (in engine)
8	VANOS accumulator
9	Pressure accumulator valve
10	VANOS Radial high pressure pump
11	Drive sprocket

VANOS Transmission

The VANOS transmission contains the “helical” cut gearing to provide the torsion or “twisting action” of the camshafts. The intake camshaft is driven by the primary chain drive from the crankshaft. The exhaust camshaft is driven by the gear-to-gear connection with the intake camshaft sprocket.

The VANOS transmissions provide the minimum and maximum “spread angle” for the camshafts. The intake camshafts have a spread angle of 60° relative to the crankshaft, and the exhaust camshafts have a spread angle of 37° relative to the crankshaft.

Due to the gear-to-gear connection between the intake and exhaust “sprockets”. The camshafts rotate in opposite directions. This means that the “retard” and “advance” movements are in different directions between the intake and exhaust camshafts.



Index	Explanation	Index	Explanation
1	Exhaust Gear	2	Intake gear

Pressure Accumulator

The pressure accumulator is pre-charged with nitrogen at a pressure of 40 bar. The oil chamber is separated from the gas chamber by a piston. The operating pressure of the VANOS is approximately 70 bar. When the engine is switched off, the pressure accumulator valve on the VANOS accumulator closes. A pressure of approximately 70 bar remains in the pressure accumulator and is immediately available the next time the engine is started. This prevents the VANOS adjustment units from producing a clacking noise when the engine is started.

Switching on and switching off conditions for the pressure accumulator valve:

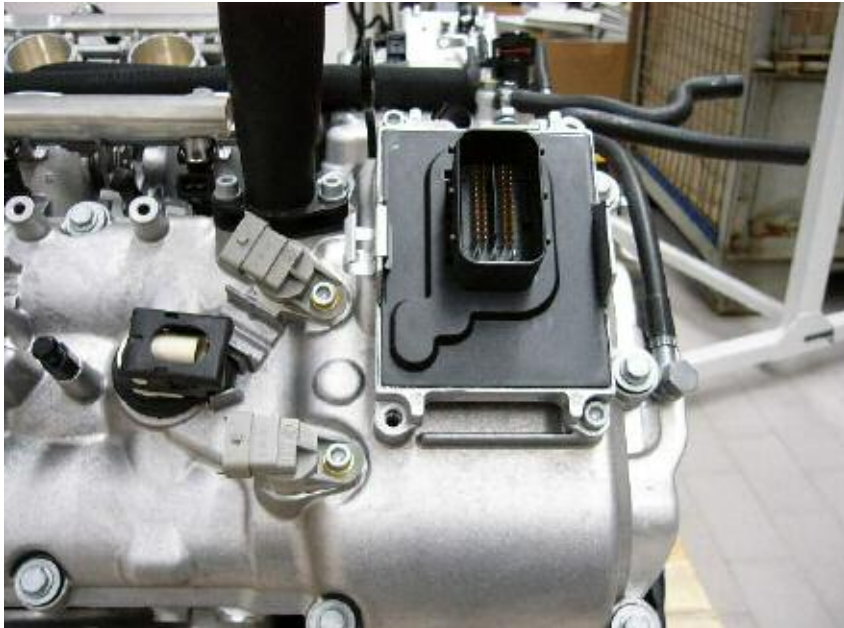
- Engine start: pressure accumulator valve OPEN
- End of engine start: pressure accumulator valve CLOSED
- Oil pressure in VANOS built up: pressure accumulator valve OPEN
- Switch off the engine: pressure accumulator valve CLOSED

Pressure Accumulator Shut-off Valve (VANOS)

The shut-off valve, which is controlled by the ECM, ensures that the high pressure engine oil remains in the pressure accumulator after turning off the engine. The valve is therefore closed when no power is applied and is opened on request by the DME (no proportional opening).

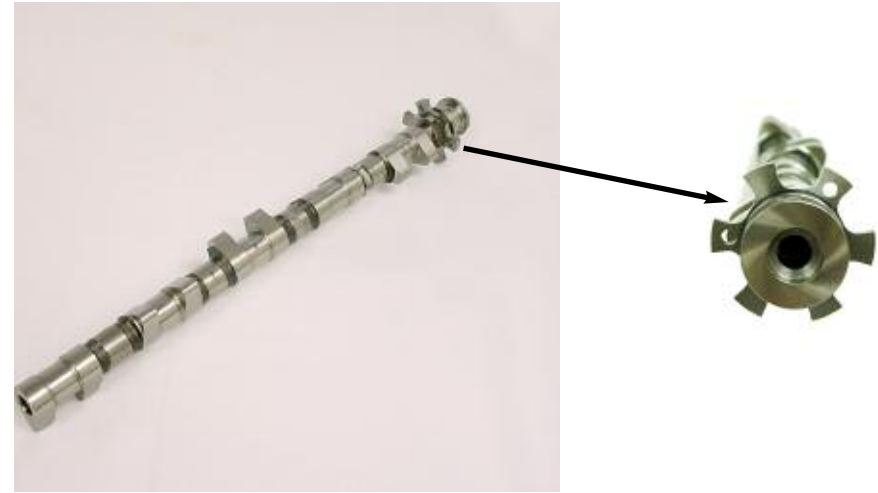
Camshaft Sensors

The hall-effect camshaft sensors are located on top of the valve cover. They provide the ECM with information regarding camshaft position. The sensors monitor trigger wheels which are integrally cast on the camshafts.



Camshaft Trigger Wheels

The trigger wheels for the camshaft sensors are integrally cast onto the camshafts.



Power Button

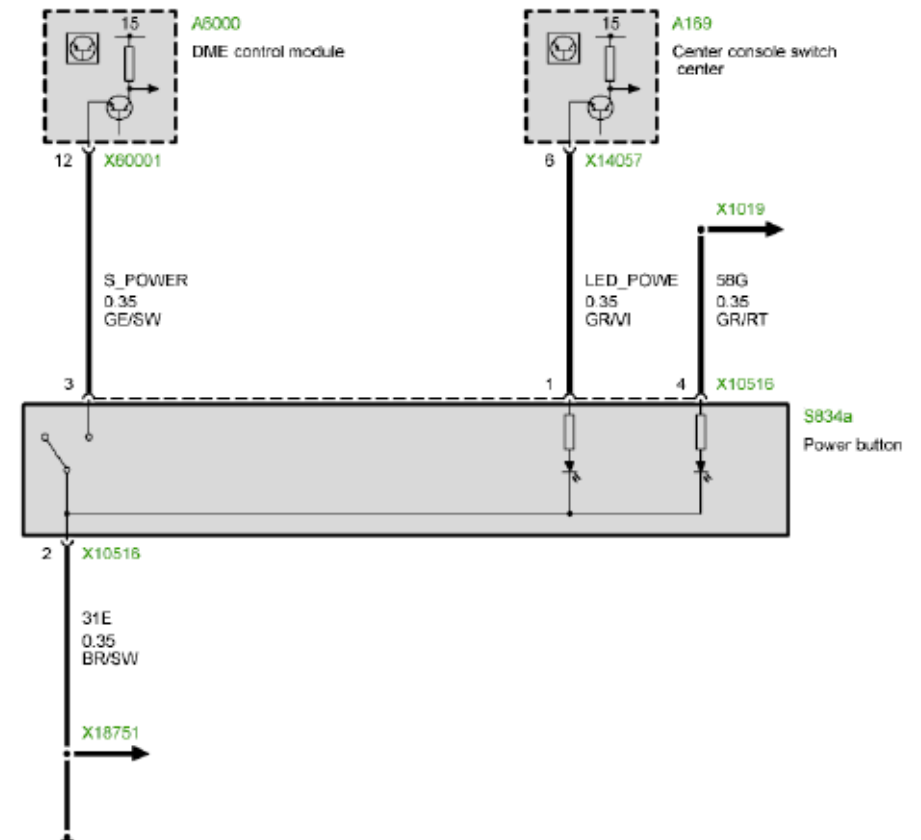
The POWER button provides a ground input to the ECM to allow selectivity of engine power output. The modes that can be selected with the button are P400 and P500.

The P500 Sport mode which also selects a progressive accelerator pedal characteristic can be configured only in the "M-Drive" menu and selected via the "M" button on the multifunction steering wheel.

The P400 setting is assumed automatically when the vehicle is restarted.



The DME receives the ground input from the switch. The SZM is responsible for the illumination of the "On" LED. Switch illumination is provided by the KL58g circuit.



Lubrication System

The lubrication system on the S85 uses “lateral force compensation”. This system is used to counteract the forces encountered during extreme cornering. This oiling system is unusually elaborate for a passenger car.

There are a total of 4 oil pumps (not including one for VANOS), that supply the S85 engine with lubrication. Of the four oil pumps used for lubrication, two of them are mechanically driven from the crankshaft by a chain drive. The other two oil pumps are electrically controlled by the ECM.

Since the E60 M5 is capable of cornering forces in excess of 1g, a potential for a loss of lubrication could be experienced. This extreme force will hold oil in the cylinder head on the cylinder bank which is on the outside of the turn which in turn could present the potential for oil starvation at the oil pump inlet.

To prevent this, there are two electrically operated “duo-centric” oil pumps located on the left and right sides of the oil sump. The ECM receives lateral acceleration information from the Dynamic Stability Control via the PT-CAN connection. If the lateral acceleration exceeds 0.8g, the ECM activates two electric oil pumps which transport oil from the cylinder head to the main oil sump.



Electrically operated “duo-centric” oil pump (Left side shown)

Oil Pressure Switch

The oil pressure switch is a ground input to the ECM. The status of the oil pressure switch is evaluated in the ECM. Any deviations from the specified value will cause the ECM to send a corresponding message to the CID. An associated check control message will also be displayed.

Oil Level Indicator

The M5 is equipped with an electronic oil level indicator. The display is selected with the BC control.

The oil level is indicated in the information field of the on-board computer (BC) in the instrument cluster.

The sensor is the quality and condition sensor (QLT) from the E65. The entire measurement logic is resident in the engine management (MS_S65) control unit.



Index	Explanation
1	Oil Level
2	Maximum Level Mark
3	Minimum Level Mark

The long-term value last stored is shown after starting the engine.

Basically there are two different measuring methods:

- Long-term Measurement
- Quick Measurement

Long-Term Measurement

The engine management permanently measures the oil level and derives the mean value from the measurement results which is then shown in the on-board computer.

The ECM requires an engine operating time of approximately 10 minutes to establish a long-term value.

Note: The average speed information was removed from the BC menu to accommodate the oil level indication in the on-board computer.

Quick Measurement

The quick measurement method provides the option of measuring the oil level with only a short time delay (e.g. topping up oil, oil service).

The quick measurement must be initiated manually by pressing and holding the BC button (approximately 2 seconds) in the oil level indication setting.

The displayed value indicates the quantity of oil above the minimum level. The value should be between MIN 0.0 l and MAX 1.0 l.

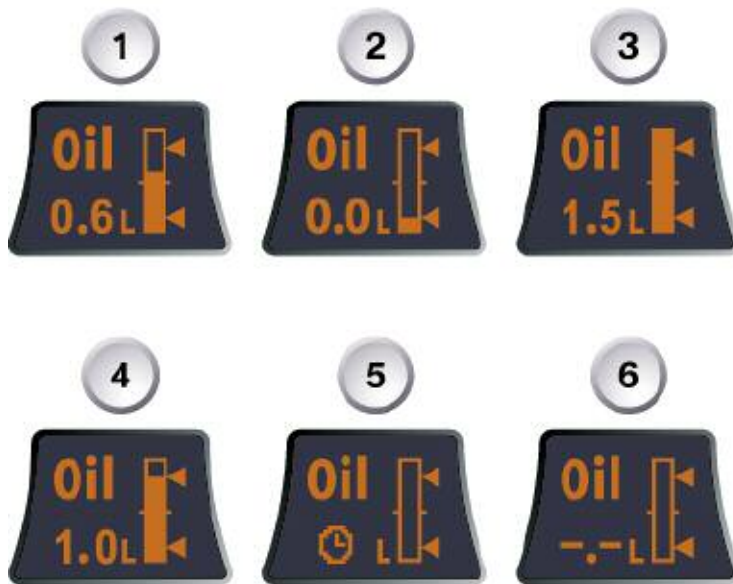
Display: 1.5 l means overfilled, the bar indicator is additionally filled above Maximum.

Perform Quick Measurement

- Park vehicle in horizontal position
- Engine running at idle speed
- Oil temperature above 70°C
- Select engine oil level indicator in on-board computer
- Press and hold BC button > 2 seconds.

The oil level display changes and shows only two dashes (see below) and a clock symbol. The clock symbol indicates that the oil level is being measured. The clock symbol would disappear if the engine speed is now increased. The measurement is continued as soon as the measurement criteria are met again.

The pure measuring time is approximately 60 s. The long-term value last stored is deleted with initiation of the quick measurement.



Index	Explanation
1	Oil level correct (0.6 liter minimum)
2	Oil level at minimum
3	Overfilled (bar full and 1.5 liter shown)
4	Oil level at maximum
5	Rapid measurement in progress
6	No value can be calculated at the moment

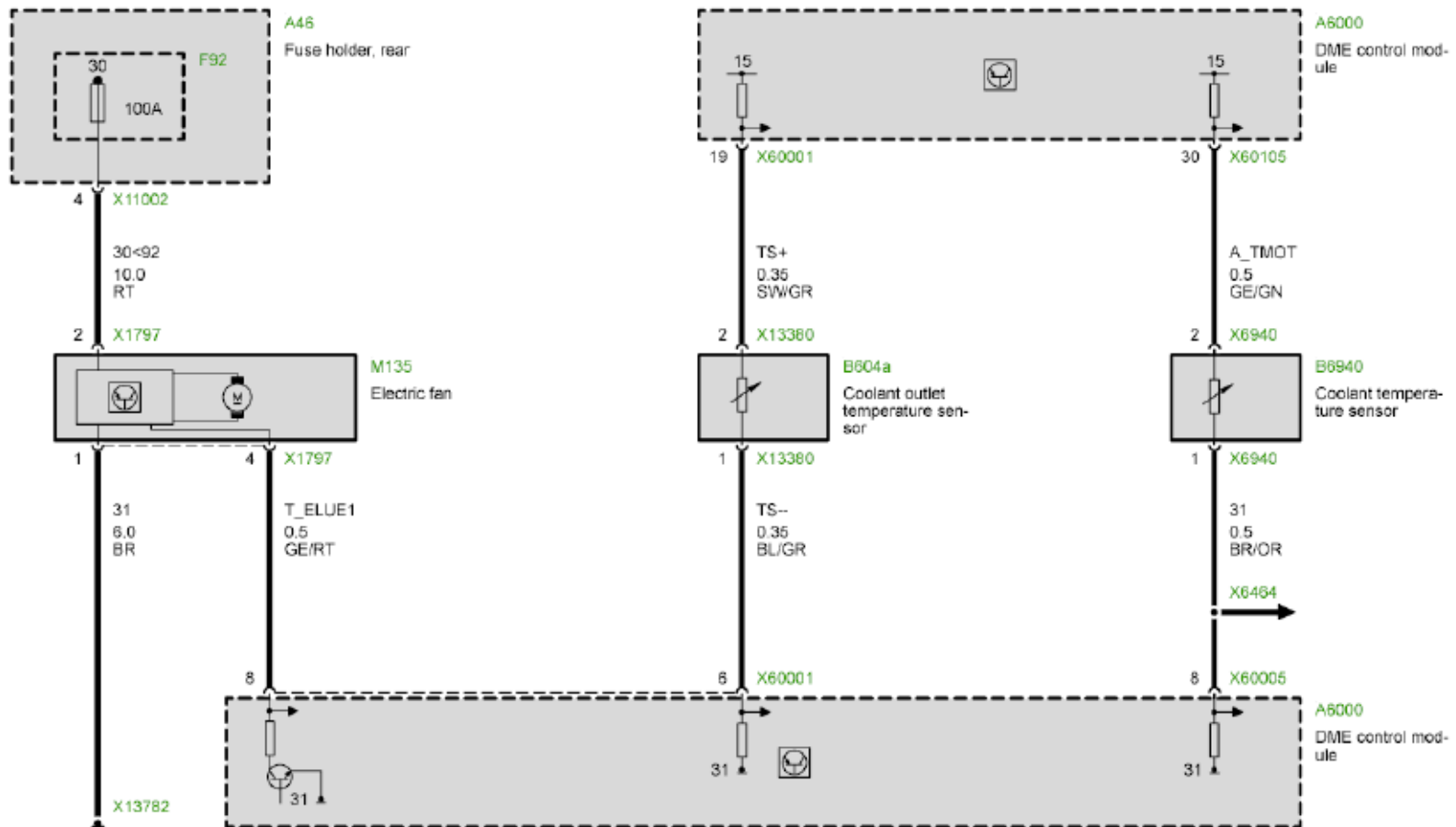
Cooling System

The cooling system on the S85 is not influenced by the ECM. In other words, the coolant thermostat is **not** electrically heated by the ECM. However, the ECM still provides control for the electric cooling fan as in past models.

The cooling fan is controlled by the ECM through an output stage which receives a PWM signal.

The ECM varies the PWM signal based on the following factors:

- Coolant outlet temperature
- Calculated (and measured) catalyst temperature
- Vehicle speed
- Battery voltage
- Air conditioning inputs (such as AC pressure)





Classroom Exercise - Review Questions

1. With regard to the “Ionic current measurement” technology, what components are no longer necessary on the S85 (and why)?

2. What are the (2) functions the spark plug is responsible for on the S85 engine?

3. When the vehicle is started, what “Power” mode is selected automatically (by default)?

4. Where are the CAN terminating resistors located on the DK-CAN and the LL-CAN?

5. What component(s) is responsible for the triggering of the ignition coils?



Classroom Exercise - Review Questions

6. How is the fuel pressure checked on the S85 engine?

7. What is the purpose of the two electric oil pumps?

8. How are the fuel pumps controlled on the S85?

9. Does the camshaft trigger wheel need to be adjusted? (Why or why not?)

10. What is the purpose of the electric vacuum pump?

NOTES

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